INTERSERVICE RADIO PROPAGATION LABORATORY
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C.
Organized under Joint U.S. Communications Board

18 July 1945

PREDICTED F2-LAYER FREQUENCIES THROUGHOUT THE SOLAR CYCLE, FOR SUMMER, WINTER, AND EQUINOX SEASON.

Contents

(over)

I. Introduction

The predictions of F2-layer frequencies presented in this report are intended to serve as a rough survey of the range of frequencies available for reliable high-frequency radio communication over long transmission paths (4000 km or greater) throughout the entire cycle of solar activity. For this purpose, the months of June, September and December were chosen as being, together, generally representative of extreme conditions, at all locations, for any given degree of solar activity.

For shorter distances (and very rarely at long distances), high-frequency transmission is sometimes controlled by the E layer, whose characteristics do not change with solar activity to as great an extent as do those of the F layer. The predictions herein are, however, applicable for the calculations of F2-layer transmission over short distances, so directions for their use in this respect are given in this report.

Sometimes, particularly during periods of low solar activity, transmission is possible by sporadic-E ionization on higher frequencies than those for the F layer. Prediction of sporadic-E transmission is not nearly as reliable as that of F2-layer transmission.

Neither regular E layer nor sporadic-E predictions are included in this report.

II. Prediction Method

Prediction charts were constructed for each of two periods of widely different solar activity, one characterized by a sunspot number of 0, the other by a sunspot number of 100.

These were derived as follows:

1. Latitude variation curves were made of the zero and 100 sunspot number intercepts of the approximately linear trend curves of twelve-month running average of monthly average f^oF2 correlated with twelve-month running average of monthly average sunspot number, for each hour of the day, for each ionosphere station from which these data are available. (Cf. IRPL-R4, "Methods Used by IRPL for the Prediction of Ionosphere Characteristics and Maximum Usable Frequencies", and IRPL-R11, "A Nomographic Method for both Prediction and Observation Correlation of Ionosphere Characteristics".)

All cases of zero sunspot number intercept necessitated a short extrapolation of these curves, although relatively little error is entailed in this process.

The preponderance of cases for a sunspot number of 100 entailed considerably greater extrapolation. Because of this, as well as of the relative unreliability of some of the earlier ionospheric data from various stations, greater error is likely in these intercept values.

Smoothing of these latitude variation curves was done with regard to the relative reliability of data from various sources, and with regard to

the general concepts of ionospheric behavior (effects of longitude, hemisphere, auroral zone, and magnetic equator, for example) used in making the regularly issued prediction charts of the IRPL-D series, "Basic Radio Propagation Predictions Three Months in Advance" (Army TB11-499 series, Navy DNC-13-1 series).

For each hour, at each station, a constant monthly index was assumed -- the average for all available data. (Monthly index = monthly average f^oF2/twelve-month running average f^oF2). Likewise, a constant muf factor was assumed for each hour at each station. Since neither of these quantities actually is constant, but shows a slight variation with solar activity, these assumptions involve a slight amount of error, but were made in order to enable the predictions to be presented in a simple nomographic form. (Cf. the previously cited reports, IRPL-R4, and IRPL-R11).

Smoothed-latitude variation curves were made, for each hour, of the monthly indexes and of the F2-M4000.

Values of the latter, for each ten degrees of latitude are presented in Tables I and II.

The product of the predicted twelve-month running average f^oF2, at each hour, for any location, and the corresponding monthly index, is the predicted monthly average f^oF2 shown on the charts of Figs. 6 through 23.

Any pair of such values, at a given time and location, for two different sunspot numbers, establishes the locus of the point for that hour and location on the central curve, A, of a nomogram of the type shown as Fig. 24. (Cf. IRPL-R11). From these nomogram curves, predicted values of f^oF2 may be obtained, throughout the entire range of solar activity, for that location.

Multiplication of the f^oF2 at any hour and location, by the appropriate value of F2-M4000, as given in Tables I and II, gives the value of F2-4000 muf for that hour and location. This multiplication may be performed byfore laying out the central nomogram curves, the result being a nomogram giving values of F2-4000 muf rather than f^oF2 (of the type of Figs. 9, 10 and 11 of IRPL-R11), this being the practical type for use in consideration of long-distance transmission. Alternately, if both f^oF2 and F2-4000 muf are desired, the nomogram may be constructed giving values of f^oF2, as previously indicated, and a second central scale, B, introduced, as shown in Fig. 24 of this report. This scale, which is a portion of the line connecting the zero values of f^oF2 and F2-4000 muf, effects multiplication of the values of f^oF2 by the corresponding value of M-4000 for each hour.

The accuracy of these predictions in the proximity of old ionosphere stations, for example, at Washington, D. C., Watheroo, W. Australia, and Huancayo, Peru, should be fairly good. The most doubtful values are probably for the equatorial regions where the latitude gradient of f^oF2 is particularly high, and for the southern hemisphere, W zone, south of Huancayo, Peru, where no ionosphere data over long periods of time have been reported, and therefore where the predicted values must be estimated from data for other zones.

Observed values of F2-M4000 are not available, at present, for high sunspot numbers; those presented in Tables I and II are obtained from the average for all available data, these being the result of observations taken variously during the past four years. Since maximum usable frequency factors show a consistent slight decrease with increasing sunspot number, values of muf obtained by means of them will be slightly too high for periods of high solar activity. On the basis of the observed variation in F2-M4000 at Washington, D.C., for which the most reliable correlation exists, the amount of this error will be approximately 5% for a sunspot number of 100.

III. Method of Construction of Prediction Nomograms from Basic Charts and Tables

1. Determine the location, length, and "control points" or midpoint, of the transmission path.

(a) Place a piece of transparent paper over the map, Fig. 1, and draw upon it a convenient reference latitude line (i.e., either pole, or the equator), the locations of the transmitting and receiving stations, and the meridian whose local times are to be used as the times for calculation.

(b) Place this transparency over the great-circle chart, Fig. 2, and, always keeping the reference latitude line at the proper position, slide the transparency horizontally until the terminal points of the transmission path either fall on the same great-circle curve, or fall the same proportional distance between adjacent great-circle curves. (Great-circle curves are those intersecting on the equator in Fig. 2). Draw in the path.

(c) Determine the length of the transmission path. This may be done by counting the number of spaces between small-circle curves crossing the path. (The oval curves with centers at the intersection points of the great-circle curves of Fig. 2 represent "small circles" on the earth's surface, spaced at 1000-km intervals about a common center on the equator.)

(d) If the path length is under 4000 km, locate the midpoint. If it is over 4000 km, locate the two transmission "control points", --those points on the path, distant 2000 km, each, inward from either end.

(e) Determine the latitude, longitude, and zone of the midpoint or control points by placing the transparency over the world map, Fig. 1.

(f) Determine the difference between the local time at the midpoint, or at each of the control points, and that at the meridian whose local times are to be used at the times for calculation. This time difference, in hours, is equal to the longitude difference, in degrees, divided by 15. The local time is the later if the location of the point is the farther toward the east.

2. Determine the $f^{o}F2$ at 0 and at 100 sunspot number, for the midpoint or for each of the two control points.

(a) Select from the charts, Figs. 6 through 23, the pair for the appropriate zone or zones and for the month desired, or for all three months if a survey of yearly conditions is desired.

(b) Place the transparency over each of the selected charts, maintaining correct latitude alignment, and keeping the chosen time meridian aligned with the local time of day, and read off the values of f^oF2 at the midpoint, or at the control points, at each hour, for sunspot numbers of zero and 100.

3. Determine the values of F2-M4000 for the midpoint or for the control points, for each hour, from Tables I or II. These must be recorded in the local times for the meridian chosen as that for calculation, by means of the time differences determined by procedure III-1-f.

F2-M4000 vary but little with time or latitude, so that linear interpolation of the tabulated values may be made when necessary.

4. Construct the nomogram base.

For paths under 4000 km, a nomogram giving both f^oF2 and F2-4000 muf, as illustrated in Fig. 24, will be necessary.

For paths over 4000 km, nomograms of the type illustrated in Fig. 24 may be made. A simpler procedure, however, is to eliminate scale B and allow the left-hand vertical scale to be used for F2-4000 muf.

(a) The nomogram base, in either case, must consist of two parallel straight lines, of any convenient length, and at any convenient distance apart. They must be subdivided evenly, with any convenient size of subdivisions suitable for covering the desired ranges of sunspot number, f^oF2, or F2-4000 muf. (The vales of F2-4000 muf will be, in general, slightly greater than three times the f^oF2 values).

(b) The progression of values on left-hand and right-hand scales must be opposite in direction. That is, if both central scales A and B are to be used, as in Fig. 24, the values of sunspot number and f^oF2 must progress oppositely to each other and be on opposite scales, while the values of F2-4000 muf must progress in the same direction as the sunspot numbers, and may be either on the same scale line, as in Fig. 24, or a line parallel to this. If the simpler procedure, eliminating scale B, is used (Cf. IRPL-R11, Figs. 9-11), the F2-4000 muf values must be represented on the opposite, parallel scale to those for sunspot number, and must progress in opposite direction to those for sunspot number.

5. Locate the points on the central scales of the nomograms.

(a) Scale A, where scale B is also to be used: (Long or short paths). Align a straightedge, successively, with 0 on the sunspot scale, and the corresponding f^oF2 on the f^oF2 scale for any hour, then with 100 on the sunspot scale and its f^oF2 for the same hour. The intersection of these two lines is the locus of the point on scale A for that hour, and should be labelled with that time.

(b) Scale A (for F2-4000 muf) where scale B is not used. (For long paths only). (The left-hand scale in this case is given values for F2-4000 muf, proceeding in the opposite direction to the right-hand scale divisions for sunspot number).

Multiply the values of f^oF2 obtained from the procedure III-2, and the appropriate values of F2-M4000 obtained from procedure III-3.

Obtain the intersection point of the two lines connecting values of F2-4000 muf at 0 and 100 sunspot number with the appropriate sunspot numbers on their respective scales, in the manner used for f^oF2 in procedure III-4-a, for each hour. This likewise is the locus of the point on the curved central nomogram scale, for that hour. Repeat for all hours, labelling these points with the time in each case.

(c) Scale B. (Where procedure III-4-b is not used). (Necessary for all short-path problems).

Connect the zero points of the scales for f^oF2 and F2-4000 muf with a straight (diagonal) line.

Multiply the values of F2-M4000 obtained from the procedure III-2 by 10.

Align the number 10 on the f^oF2 scale with the values of 10 x F2-M4000 determined above, successively, for each hour. The intersections of these lines with the diagonal line form scale B, when labelled with the appropriate time.

IV. Method of Use of Prediction Nomograms.

1. For long paths (4000 km or greater):

For this case, one nomogram, for the midpoint of the path will be necessary for the distance 4000 km.

For greater distances, two nomograms will be necessary, one for each control point.

(a) If these are of the simpler type (procedure III-4-b), align the value of the sunspot number for the time of prediction with that of the time of day on the central curve of the nomogram. The intersection of this line with the F2-4000 muf scale gives the corresponding value of this quantity. Repeat for all hours, or those desired. If the path is 4000 km long, this will be the F2-4000 muf for the path. If the path is greater than 4000 km, values obtained in the above manner for each control point should be compared for the same times. The lower of the two values is the F2-4000 muf for the path.

(b) If the nomograms are of the type of Fig. 24 (procedure III-4-a and c): Align the value of the sunspot number for the time of prediction with that of the time of day on scale A. The intersection of this line with the f^oF2 scale gives the appropriate value of f^oF2. Align this value of f^oF2 with the position on scale B for the same time of day. The intersection of this line with the F2-4000 muf scale gives the appropriate value of the F2-4000 muf. Repeat for all hours, or those desired. For paths greater than 4000 km, comparison must be made of these values for both control points, at the same

time. The lower of the tow is the F2-4000 muf for the path. For paths of 4000 km length, the value of F2-4000 muf obtained for the midpoint is that for the path.

2. For short paths (under 4000-km):

(a) Determine the gyrofrequency, f_H, at the midpoint of the path from Fig. 3.

(b) Determine f^oF2 and F2-4000 muf as in procedure IV-1-b, for the case of a 4000-km transmission path.

(c) Determine the F2-zero muf at the midpoint as follows: Using the nomogram, Fig. 4, align the value of f_H determined in procedure IV-2-a with the values of f^oF2 determined in procedure IV-2-b. The intersection of the line, in each case, with the f^x or zero-muf scale gives the corresponding value of F2-zero muf.

(d) Using the nomogram, Fig. 5, align the values of F2-zero muf determined by procedure IV-2-c, and of F2-4000 muf determined by procedure IV-2-b, on the left-and right-hand scales, respectively, for each hour. Read off the value of F2 muf for the path distance at the appropriate position in the central part of the nomogram.

This value is the muf for the path only when transmission is controlled by the F2-layer. Comparison with E-layer and sporadic-E muf is necessary in order to obtain the muf for the path for all modes of transmission, this being the highest of the three values.

TABLE I

F2-[illegible] - June

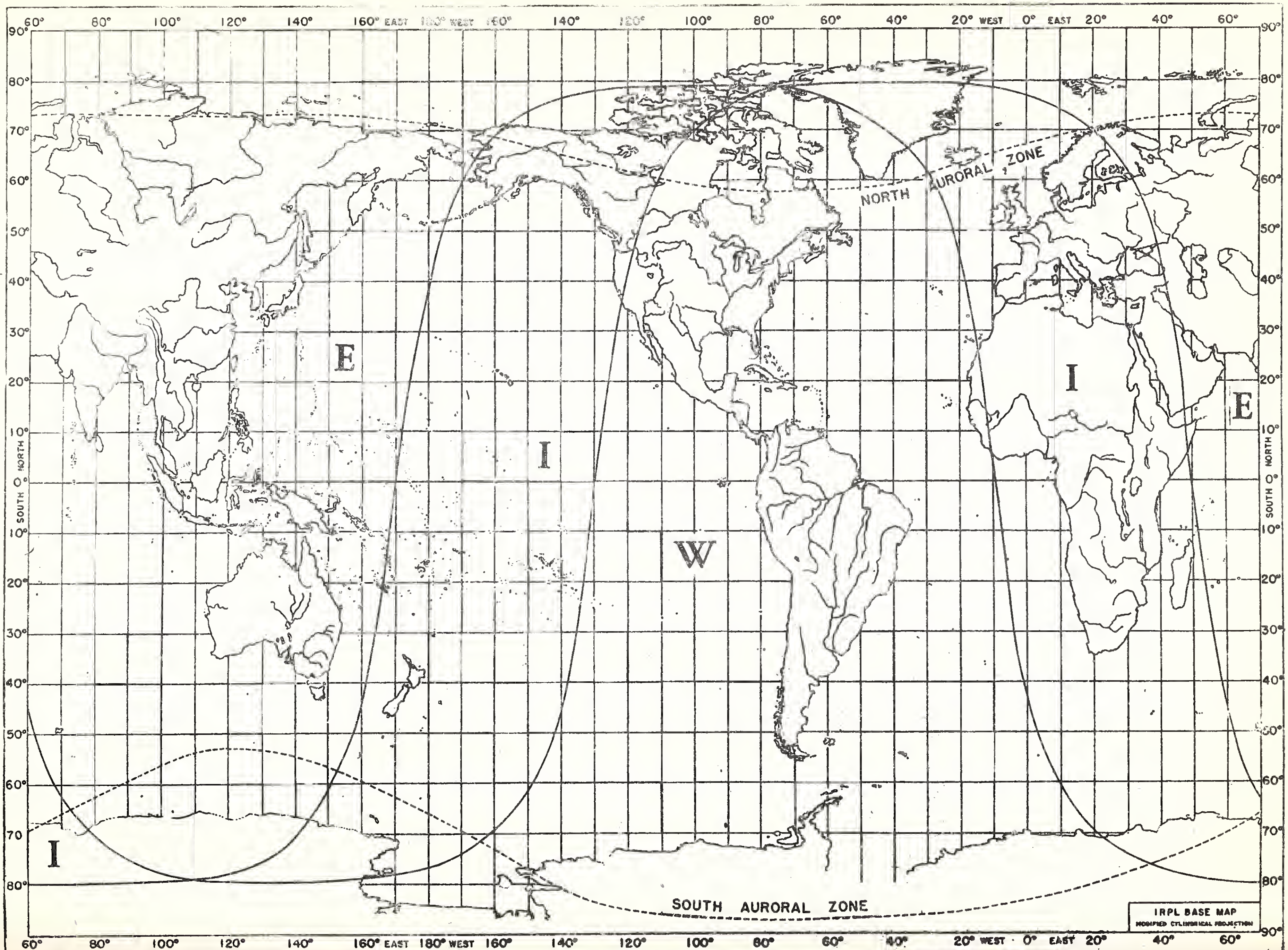
Latitude

Local Time	80°N	70°N	60°N	50°N	40°N	30°N	20°N	10°N	0°
00	3.43	3.61	3.60	3.23	3.34	3.00	3.31	3.09	3.17
01	3.51	3.59	3.55	3.20	3.32	3.13	3.48	3.22	3.38
02	3.50	3.56	3.50	3.20	3.31	3.10	3.40	3.20	3.23
03	3.52	3.58	3.46	3.25	3.30	3.12	3.38	3.37	3.34
04	3.52	3.52	3.50	3.30	3.32	3.05	3.40	3.30	3.40
05	3.43	3.45	3.49	3.40	3.49	3.20	3.45	3.35	3.38
06	3.29	3.31	3.40	3.43	3.47	3.30	3.50	3.40	3.40
07	3.29	3.24	3.10	3.30	3.33	3.27	3.40	3.39	3.37
08	3.20	3.20	3.12	3.29	3.32	3.12	3.19	3.20	3.17
09	3.18	3.20	3.20	3.27	3.27	3.03	3.03	3.06	2.98
10	3.25	3.40	3.40	3.32	3.21	3.03	3.00	2.90	2.88
11	3.40	3.42	3.23	3.20	3.18	3.01	3.02	2.84	2.77
12	3.40	3.40	3.21	3.23	3.20	3.00	3.08	2.93	2.84
13	3.31	3.33	3.16	3.20	3.18	3.04	3.16	3.02	2.87
14	3.20	3.20	3.12	3.14	3.14	3.12	3.19	3.03	2.92
15	3.20	3.20	3.20	3.23	3.19	3.14	3.25	3.07	2.92
16	3.22	3.26	3.16	3.20	3.20	3.15	3.34	3.15	2.94
17	3.30	3.35	3.28	3.26	3.34	3.20	3.50	3.21	3.05
18	3.30	3.40	3.24	3.33	3.41	3.21	3.50	3.19	3.04
19	3.40	3.41	3.48	3.31	3.45	3.30	3.50	3.21	3.20
20	3.40	3.50	3.45	3.42	3.44	3.30	3.40	3.17	3.15
21	3.53	3.60	3.41	3.42	3.42	3.16	3.30	3.14	3.25
22	3.49	3.57	3.47	3.37	3.39	3.06	3.25	3.08	3.33
23	3.47	3.58	3.35	3.26	3.37	3.06	3.25	3.10	3.23
	80°S	70°S	60°S	50°S	40°S	30°S	20°S	10°S	
00	3.61	3.61	3.50	3.13	3.30	3.46	3.46	3.55	
01	3.56	3.67	3.68	3.16	3.18	3.44	3.47	3.60	
02	3.50	3.60	3.70	3.19	3.30	3.46	3.63	3.52	
03	3.48	3.50	3.70	3.20	3.28	3.50	3.68	3.50	
04	3.50	3.62	3.80	3.20	3.30	3.53	3.46	3.50	
05	3.59	3.60	3.65	3.31	3.41	3.37	3.47	3.43	
06	3.48	3.58	3.61	3.63	3.40	3.25	3.63	3.42	
07	3.38	3.40	3.57	3.42	3.49	3.57	3.75	3.41	
08	3.31	3.36	3.50	3.74	3.70	3.49	3.65	3.21	
09	3.40	3.45	3.63	3.75	3.72	3.44	3.65	3.03	
10	3.40	3.44	3.68	3.75	3.62	3.45	3.65	2.90	
11	3.51	3.61	3.65	3.75	3.62	3.40	3.55	2.83	
12	3.56	3.67	3.68	3.80	3.60	3.36	3.50	2.87	
13	3.65	3.75	3.65	3.80	3.62	3.48	3.48	2.86	
14	3.50	3.60	3.69	3.80	3.61	3.45	3.50	2.90	
15	3.50	3.56	3.66	3.80	3.61	3.48	3.55	2.90	
16	3.50	3.59	3.66	3.71	3.64	3.50	3.55	2.92	
17	3.45	3.50	3.50	3.50	3.63	3.60	3.65	3.07	
18	3.40	3.42	3.40	3.47	3.50	3.60	3.75	3.12	
19	3.50	3.58	3.40	3.37	3.50	3.47	3.60	3.22	
20	3.50	3.63	3.45	3.38	3.45	3.39	3.50	3.20	
21	3.35	3.35	3.50	3.35	3.30	3.24	3.45	3.45	
22	3.50	3.57	3.50	3.25	3.28	3.36	3.42	3.58	
23	3.60	3.69	3.62	3.16	3.27	3.26	3.44	3.50	

TABLE II
F2-M4000 - September
Latitude

Local Time	80°N	70°N	60°N	50°N	40°N	30°N	20°N	10°N	0°
00	3.60	3.60	3.20	3.16	3.23	3.29	3.31	3.33	3.43
01	3.60	3.53	3.23	3.19	3.23	3.30	3.43	3.53	3.54
02	3.60	3.50	3.08	3.15	3.20	3.35	3.54	3.61	3.61
03	3.60	3.54	3.22	3.14	3.28	3.47	3.56	3.55	3.51
04	3.60	3.53	3.12	3.18	3.30	3.47	3.51	3.50	3.46
05	3.60	3.59	3.49	3.35	3.36	3.38	3.50	3.50	3.44
06	3.60	3.61	3.47	3.61	3.58	3.57	3.53	3.67	3.57
07	3.59	3.54	3.42	3.71	3.60	3.67	3.70	3.70	3.56
08	3.59	3.54	3.38	3.57	3.54	3.66	3.51	3.56	3.18
09	3.60	3.51	3.21	3.55	3.50	3.58	3.30	3.16	3.02
10	3.58	3.45	3.27	3.57	3.43	3.41	3.26	3.03	3.00
11	3.60	3.53	3.30	3.41	3.40	3.31	3.20	2.97	2.99
12	3.60	3.53	3.30	3.41	3.37	3.31	3.26	2.99	2.89
13	3.56	3.47	3.30	3.42	3.40	3.35	3.30	3.02	2.90
14	3.59	3.51	3.33	3.44	3.39	3.33	3.40	3.10	2.98
15	3.59	3.53	3.39	3.42	3.42	3.42	3.50	3.12	3.04
16	3.59	3.50	3.40	3.45	3.45	3.50	3.66	3.14	3.12
17	3.60	3.59	3.49	3.45	3.49	3.60	3.72	3.19	3.10
18	3.60	3.55	3.41	3.44	3.48	3.65	3.72	3.20	3.33
19	3.60	3.55	3.31	3.36	3.43	3.46	3.61	3.02	3.13
20	3.59	3.53	3.34	3.34	3.40	3.42	3.47	3.10	3.31
21	3.60	3.53	3.37	3.34	3.33	3.30	3.28	3.24	3.40
22	3.61	3.60	3.30	3.24	3.27	3.30	3.20	3.28	3.32
23	3.60	3.60	3.30	3.18	3.23	3.30	3.23	3.22	3.38
	80°S	70°S	60°S	50°S	40°S	30°S	20°S	10°S	
00	3.50	3.47	3.28	2.98	3.17	3.35	3.45	3.46	
01	3.49	3.41	3.20	3.08	3.19	3.40	3.53	3.57	
02	3.40	3.36	3.24	3.04	3.20	3.50	3.57	3.58	
03	3.49	3.34	3.18	3.01	3.20	3.40	3.57	3.50	
04	3.50	3.42	3.23	3.10	3.24	3.40	3.62	3.45	
05	3.49	3.41	3.24	3.16	3.27	3.38	3.55	3.38	
06	3.52	3.53	3.39	3.36	3.34	3.54	3.49	3.43	
07	3.59	3.53	3.43	3.61	3.55	3.65	3.66	3.54	
08	3.50	3.63	3.43	3.63	3.57	3.52	3.52	3.33	
09	3.57	3.63	3.31	3.53	3.53	3.43	3.42	3.10	
10	3.50	3.63	3.38	3.50	3.44	3.30	3.00	3.00	
11	3.57	3.61	3.26	3.43	3.38	3.36	3.37	3.03	
12	3.50	3.57	3.26	3.43	3.36	3.47	3.40	2.90	
13	3.53	3.54	3.31	3.41	3.39	3.45	3.46	3.03	
14	3.50	3.55	3.37	3.38	3.51	3.44	3.49	3.12	
15	3.50	3.53	3.40	3.39	3.51	3.50	3.54	3.12	
16	3.50	3.50	3.39	3.50	3.53	3.53	3.64	3.23	
17	3.50	3.52	3.45	3.38	3.55	3.60	3.68	3.20	
18	3.57	3.63	3.46	3.42	3.62	3.62	3.75	3.30	
19	3.50	3.53	3.46	3.36	3.54	3.50	3.60	3.23	
20	3.49	3.49	3.40	3.30	3.44	3.43	3.49	3.29	
21	3.47	3.46	3.30	3.18	3.31	3.34	3.34	3.32	
22	3.50	3.62	3.33	3.12	3.23	3.27	3.29	3.30	
23	3.50	3.50	3.37	3.00	3.30	3.30	3.27	3.30	

F2-M4000 - December. Use June values, but with reversed latitudes, i.e., for 40°N in December, use the 40°S values for June at the same time of day.



WORLD MAP SHOWING ZONES COVERED BY PREDICTED CHARTS, AND AURORAL ZONES.

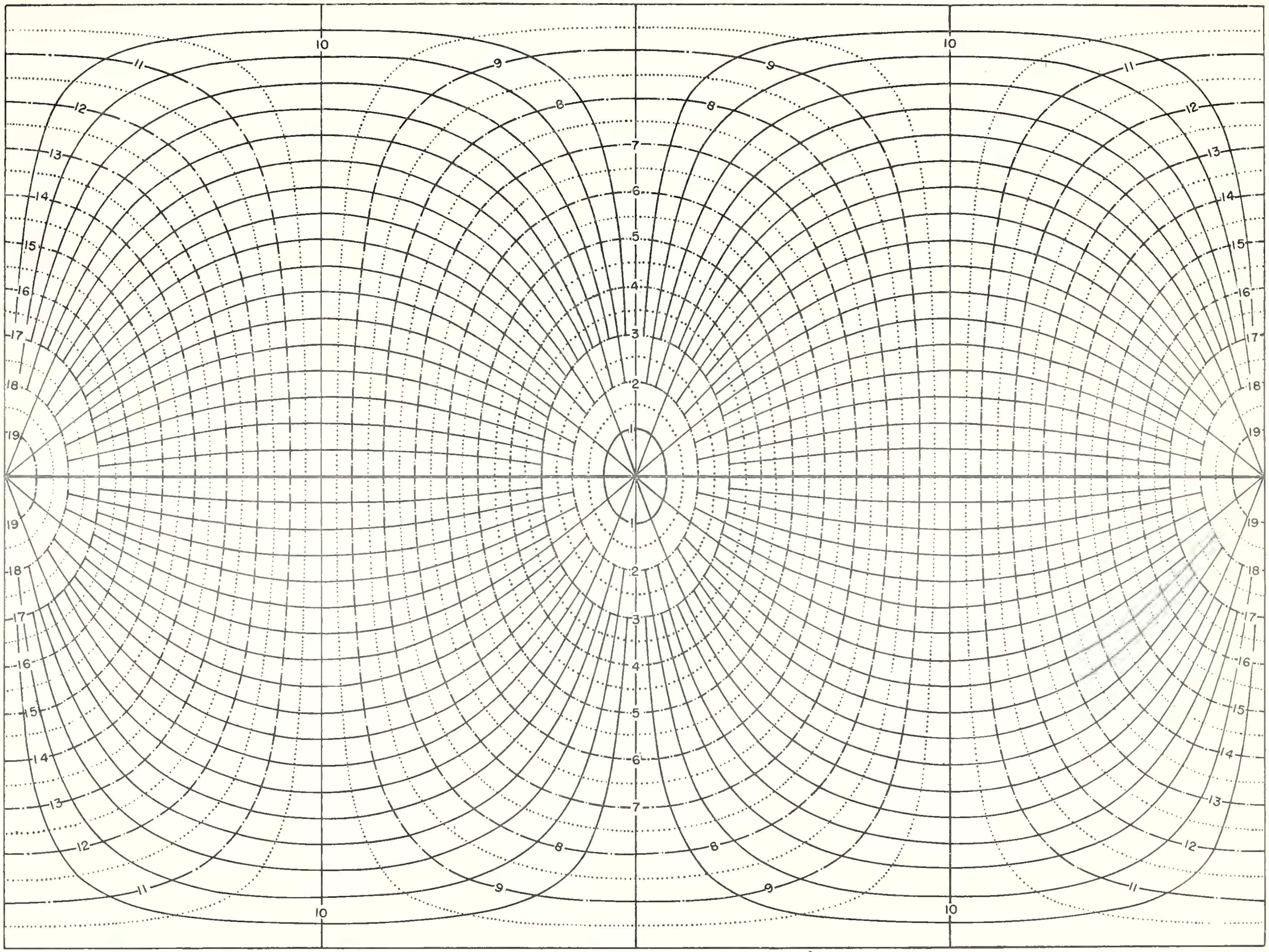


Fig. 2. GREAT CIRCLE CHART CENTERED ON EQUATOR. SOLID LINES REPRESENT GREAT CIRCLES. NUMBERED DOT-DASH LINES INDICATE DISTANCES IN THOUSANDS OF KILOMETERS.

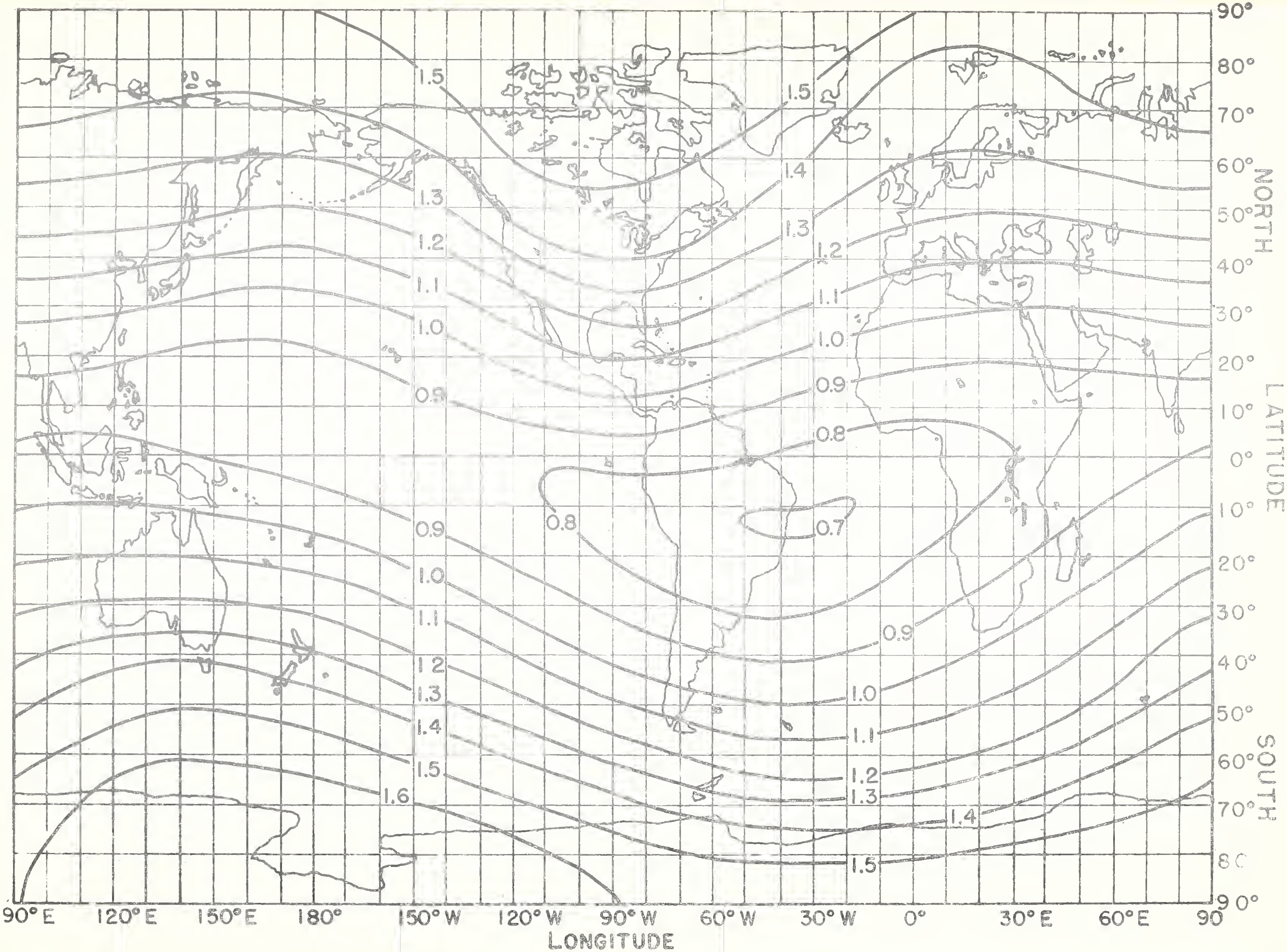


Fig. 3. Gyro-frequency map of the world. Numbers on contours are gyro-frequencies in Mc.

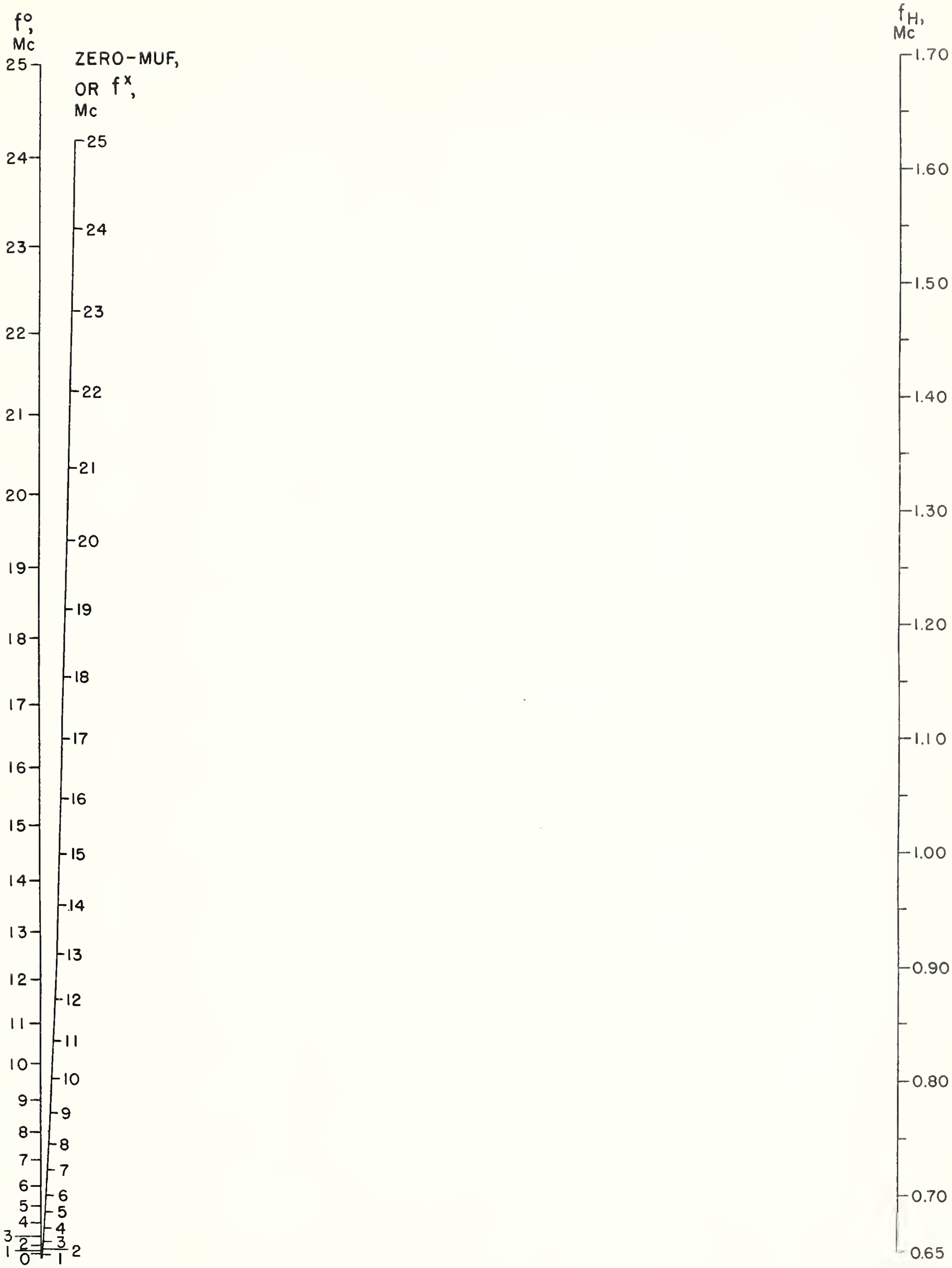


Fig. 4.
NOMOGRAM FOR OBTAINING ZERO-MUF, OR f^x, FROM f^o AND f_H.

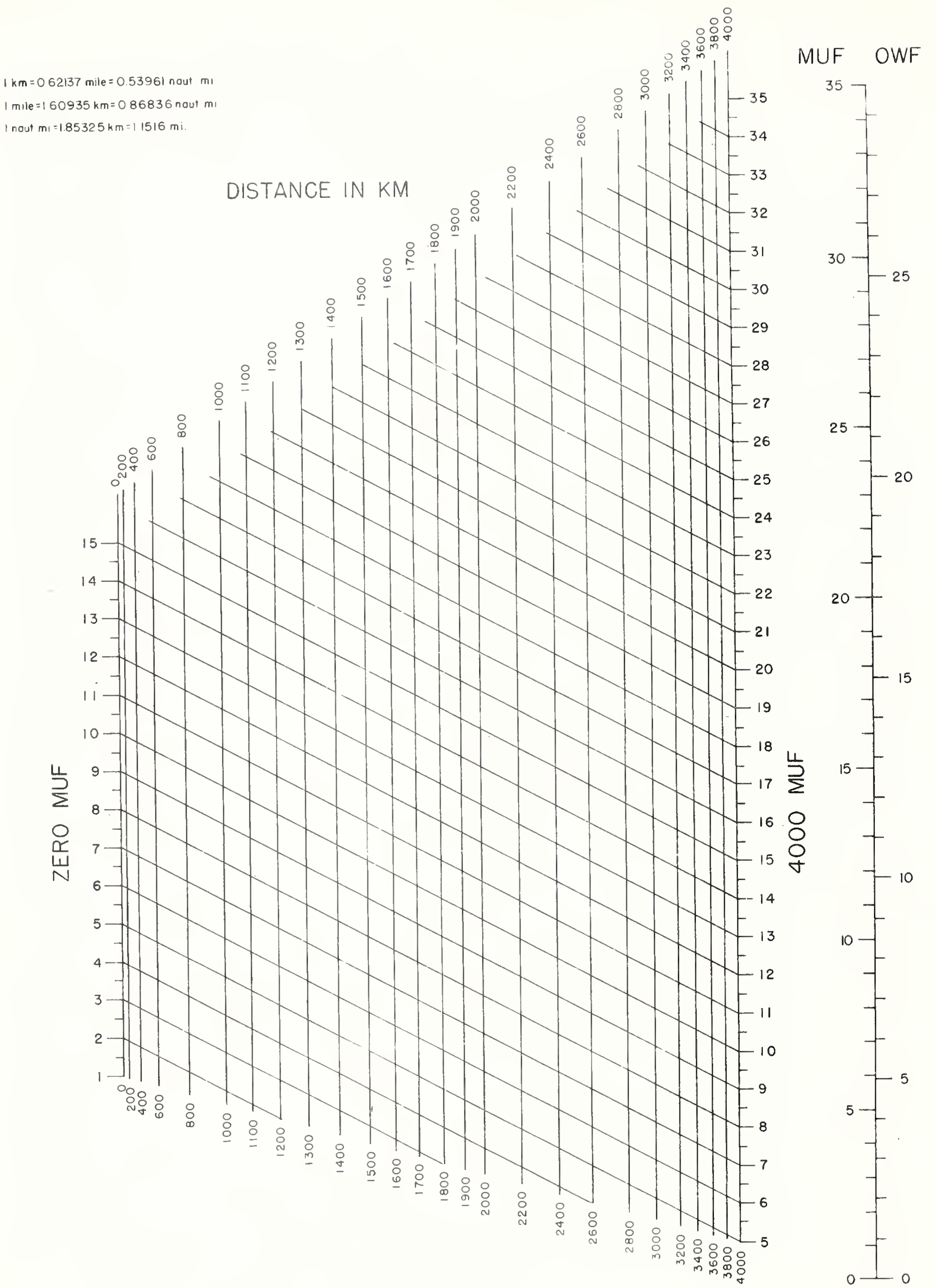


FIG. 5. NOMOGRAM FOR TRANSFORMING F_2–ZERO–MUF AND F_2–4000–MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AT INTERMEDIATE TRANSMISSION DISTANCES; CONVERSION SCALE FOR OBTAINING OPTIMUM WORKING FREQUENCIES.

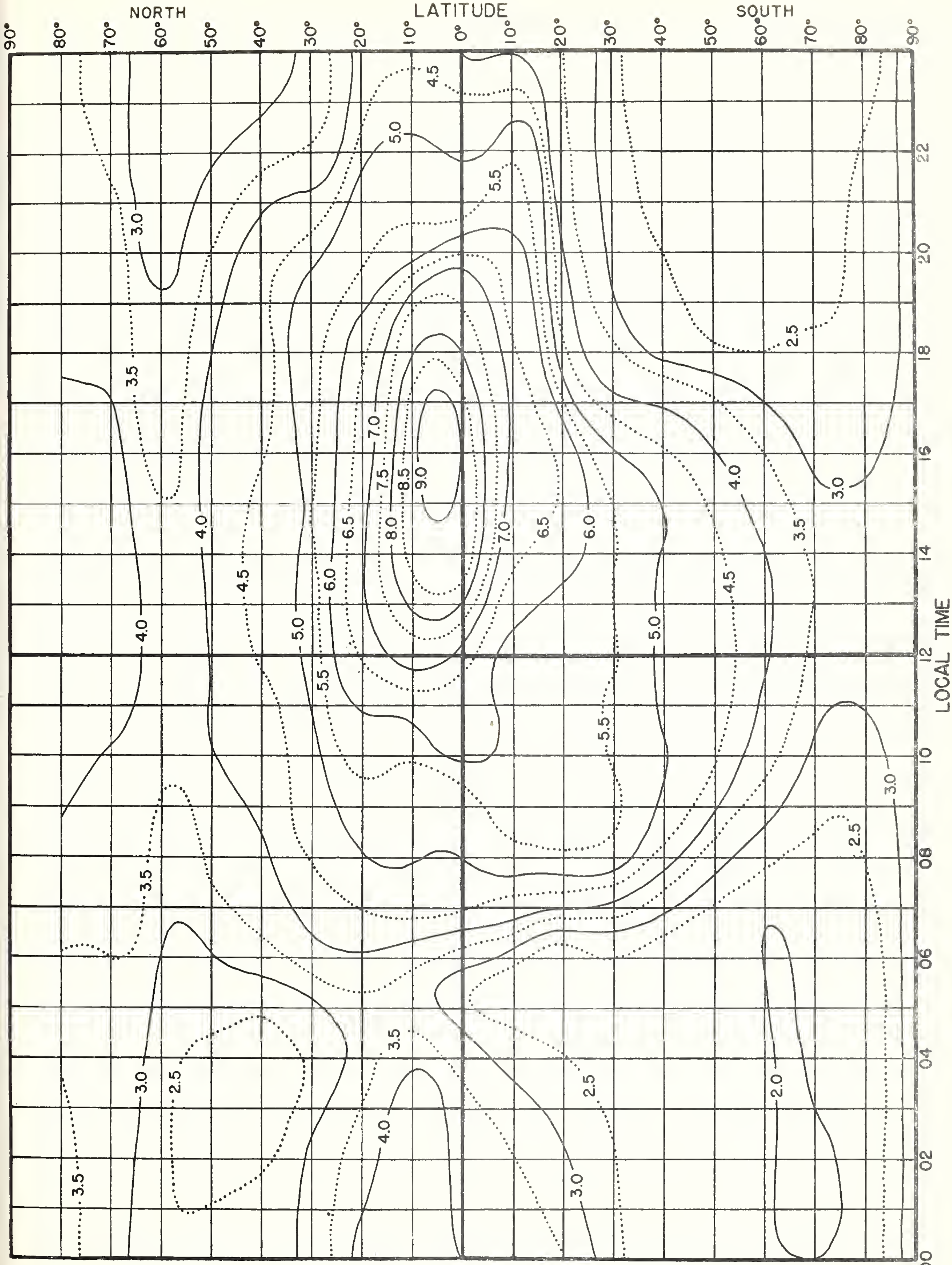


Fig. 6. f°F2, IN Mc, W ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER 0.

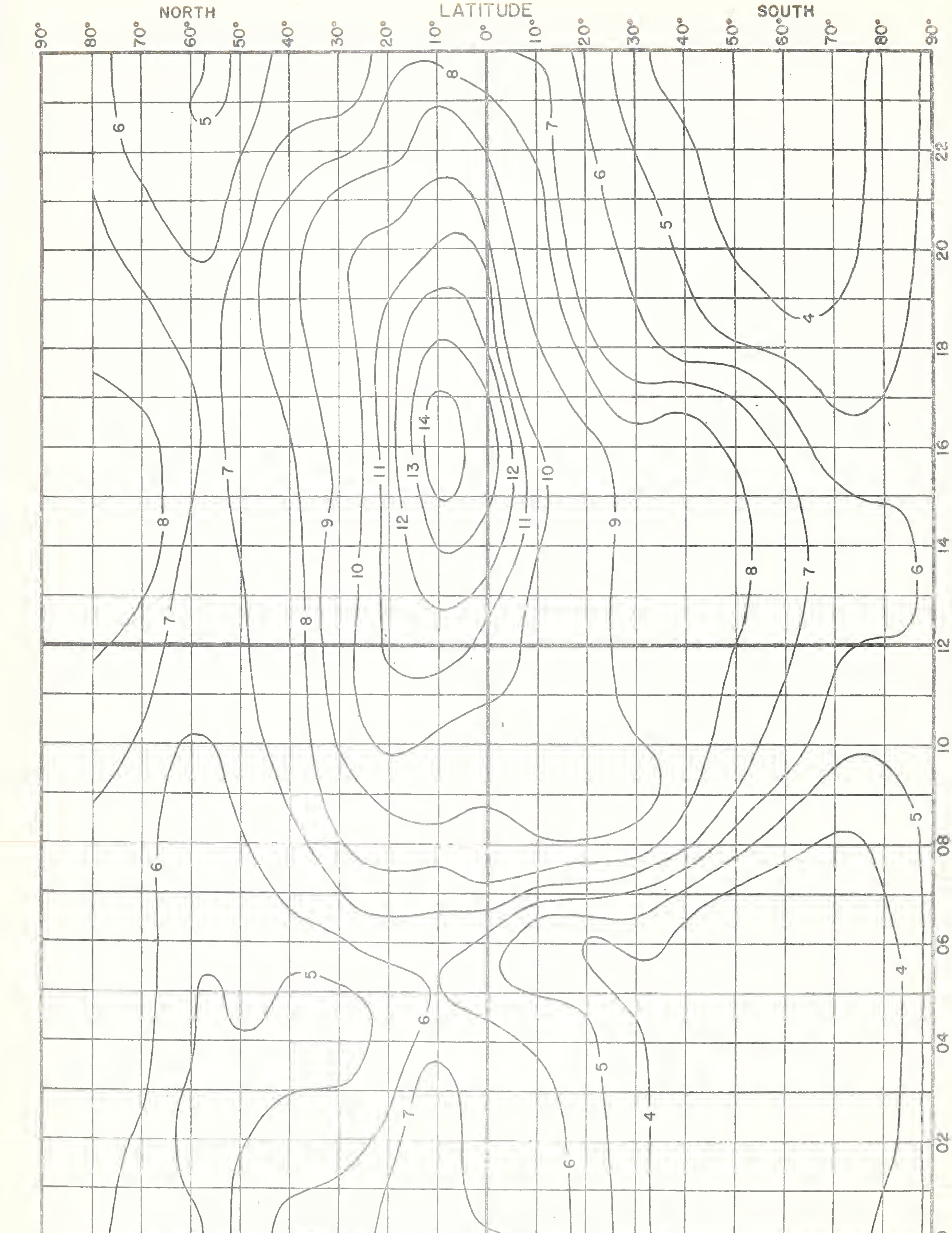


Fig. 7. f°F2, IN Mc, W ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER 100.

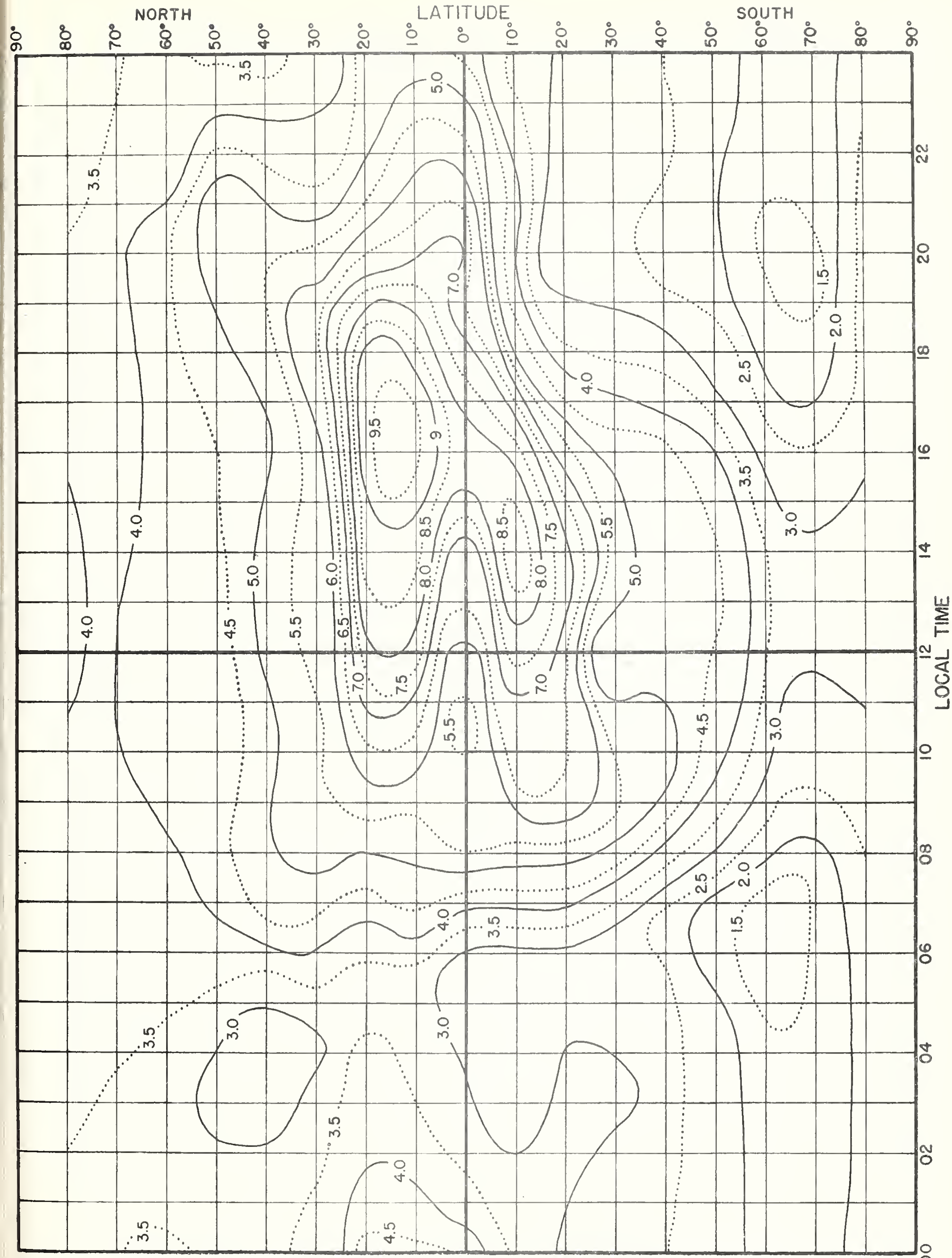


Fig. 8 f°F2, IN Mc, I ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER O.

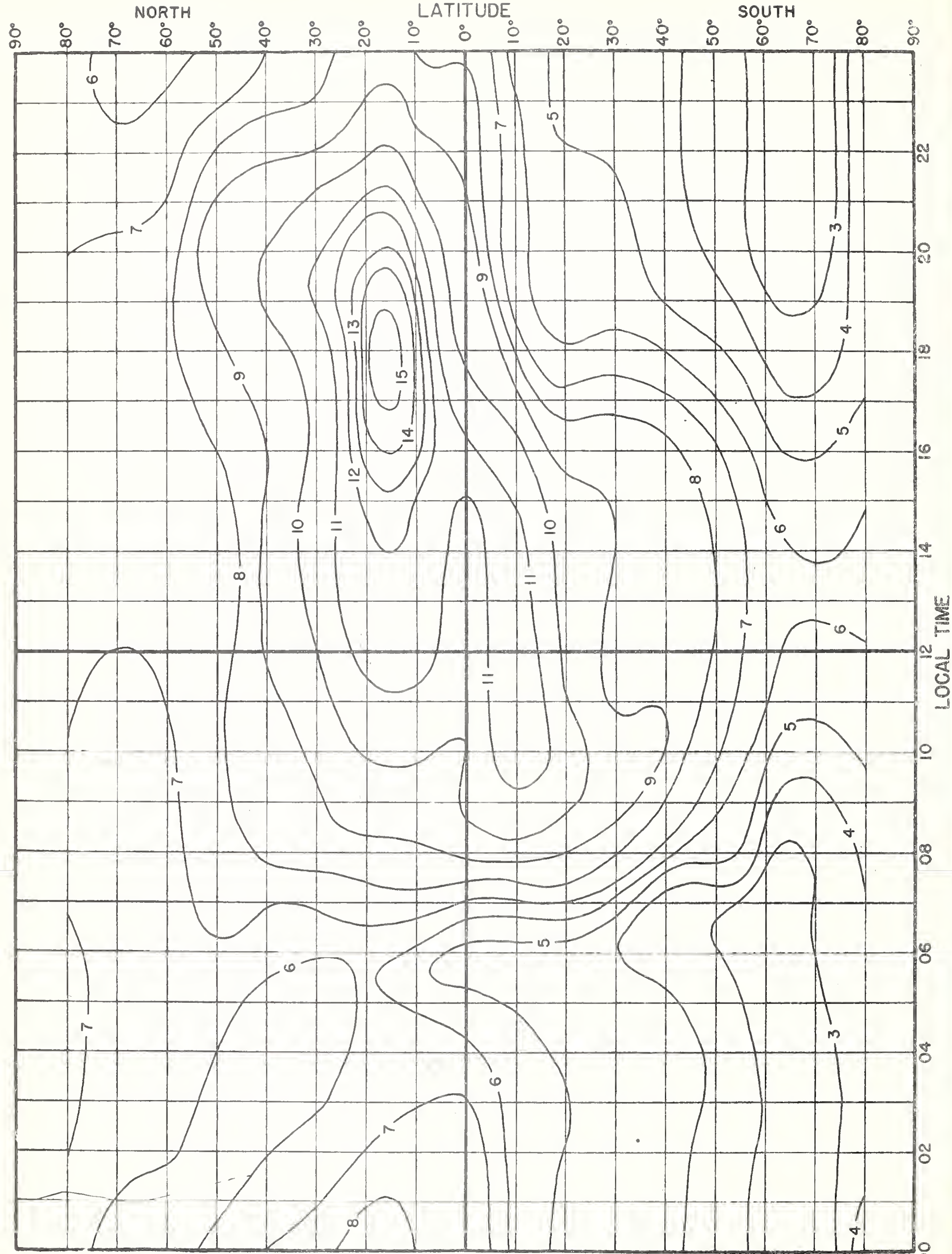


Fig. 9. f°F2, IN Mc, I ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER 100.

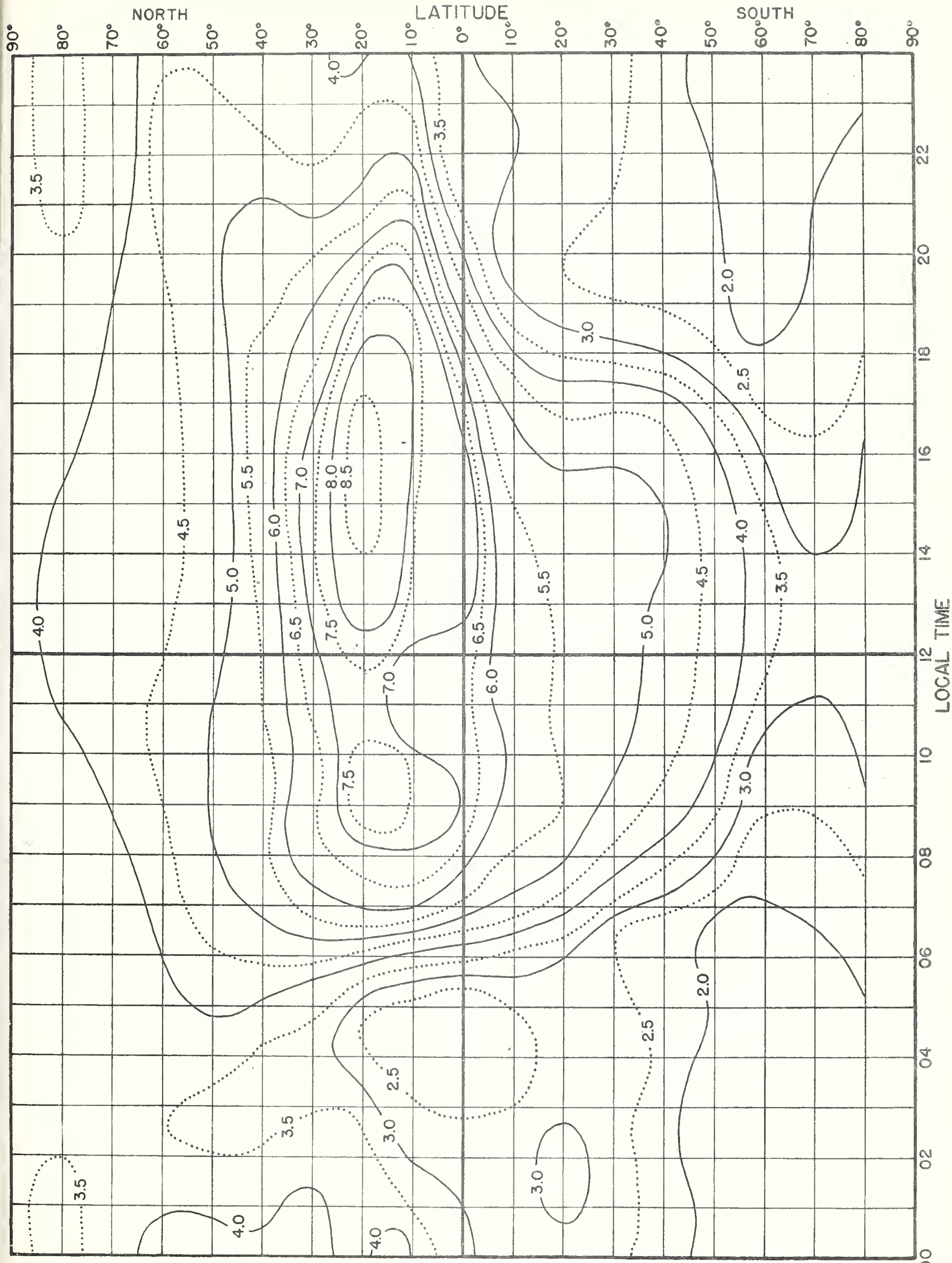


Fig. 10. f°F2, IN Mc, E ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER 0.

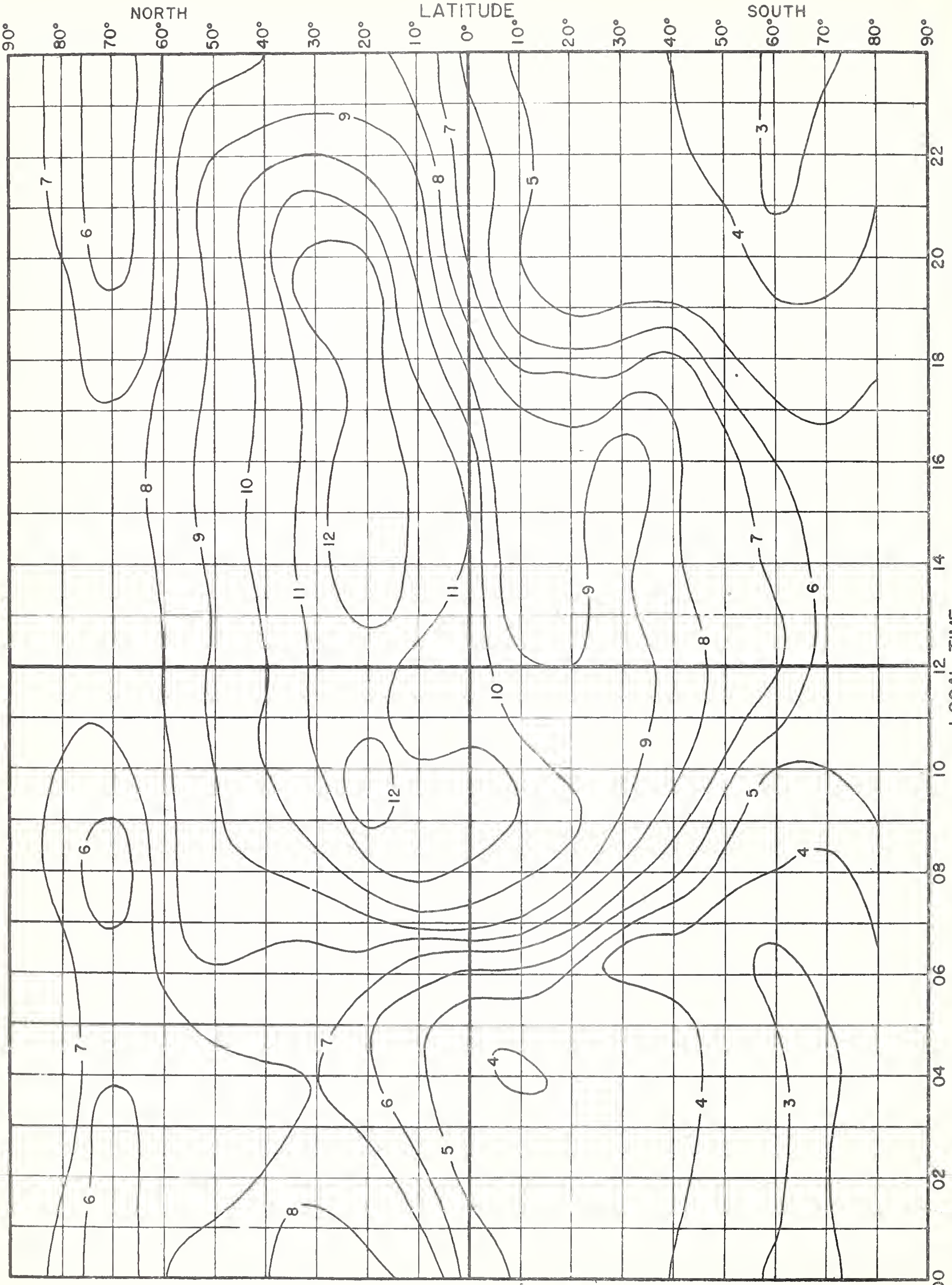


Fig. 11. f°F2, IN Mc, E ZONE, PREDICTED FOR JUNE, SUNSPOT NUMBER 100.

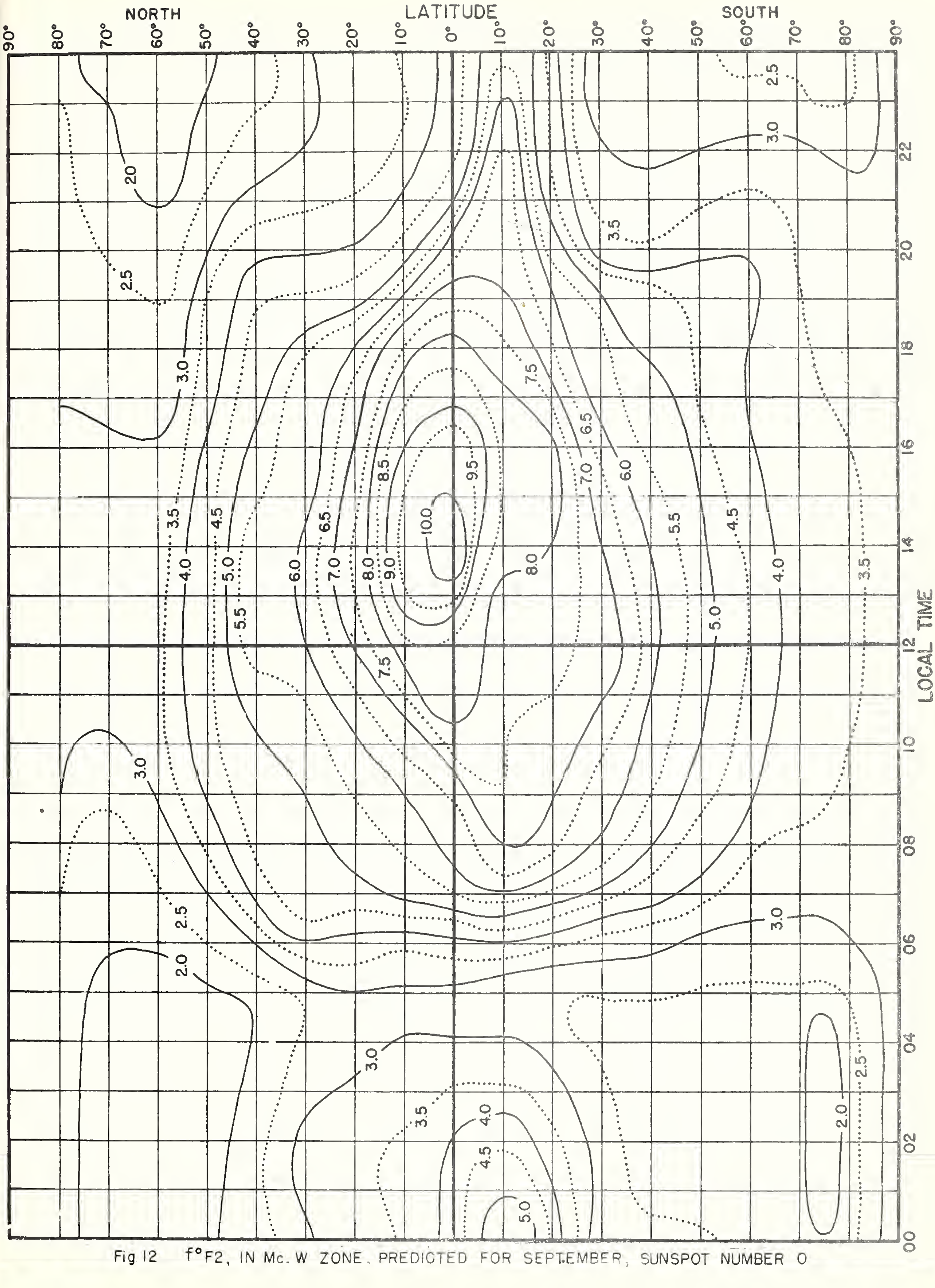


Fig 12 f°F2, IN Mc. W ZONE. PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 0

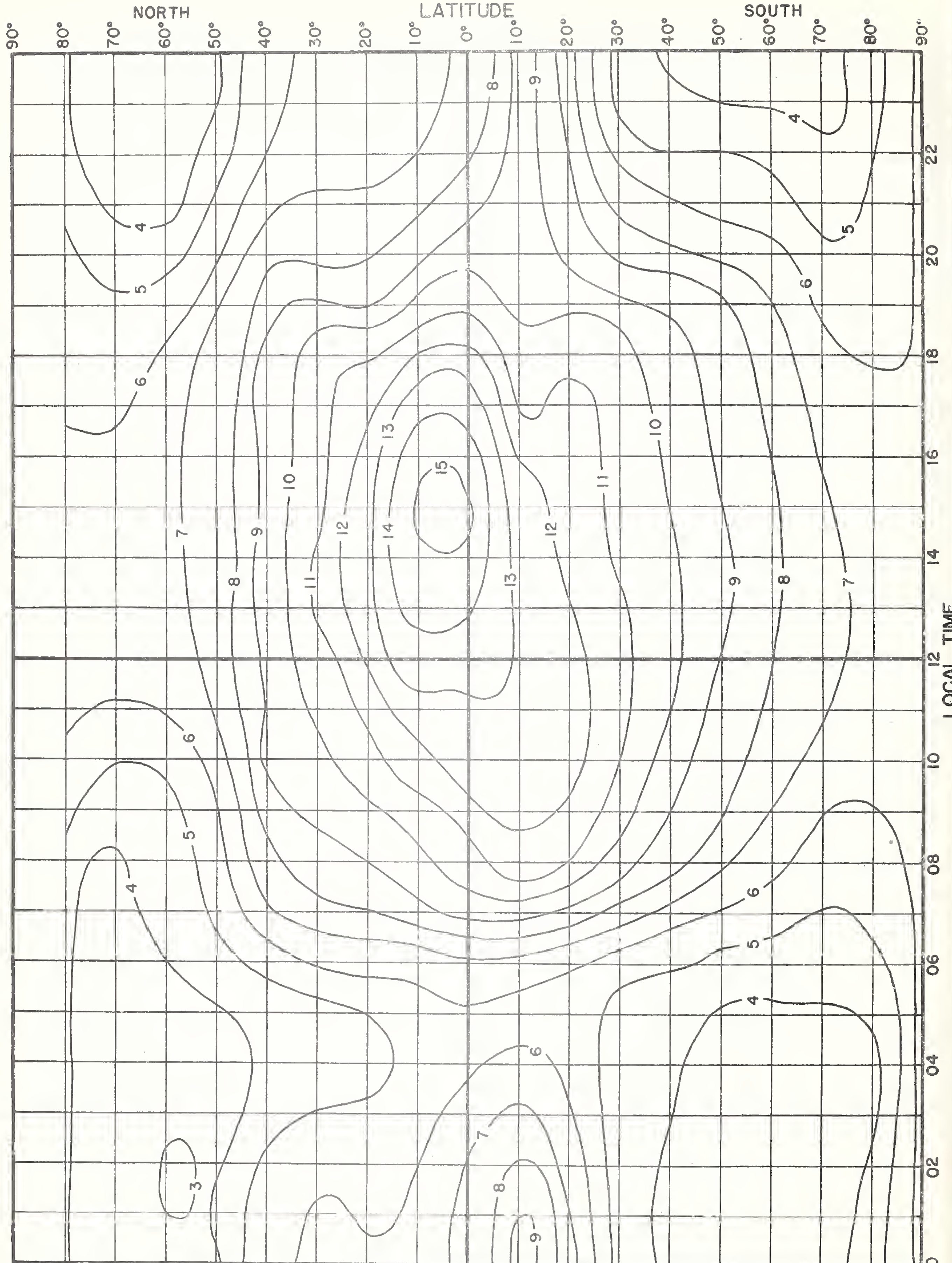


Fig. 13. f°F2, IN Mc, W ZONE, PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 100.

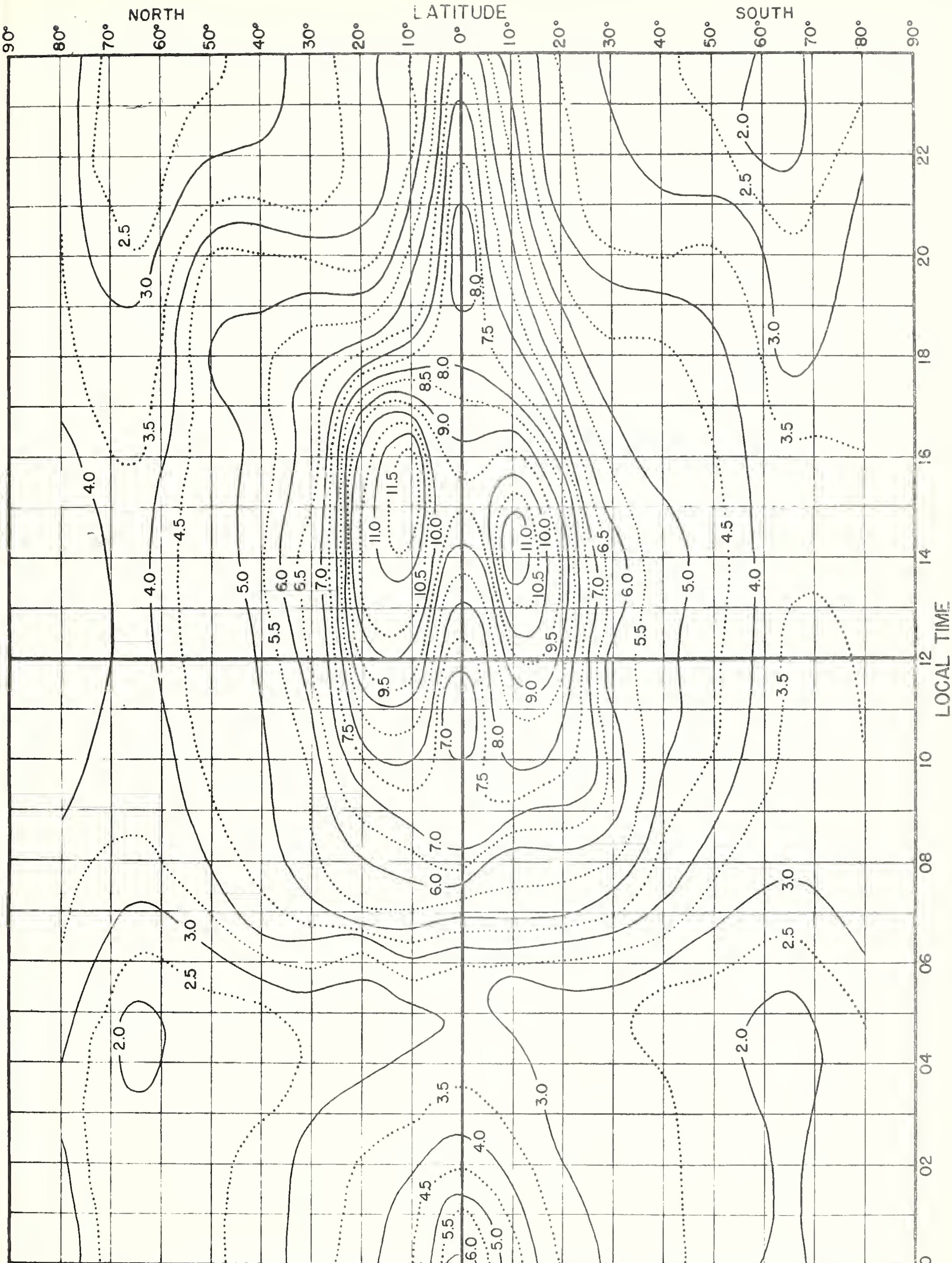


Fig 14 f°F2, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 0.

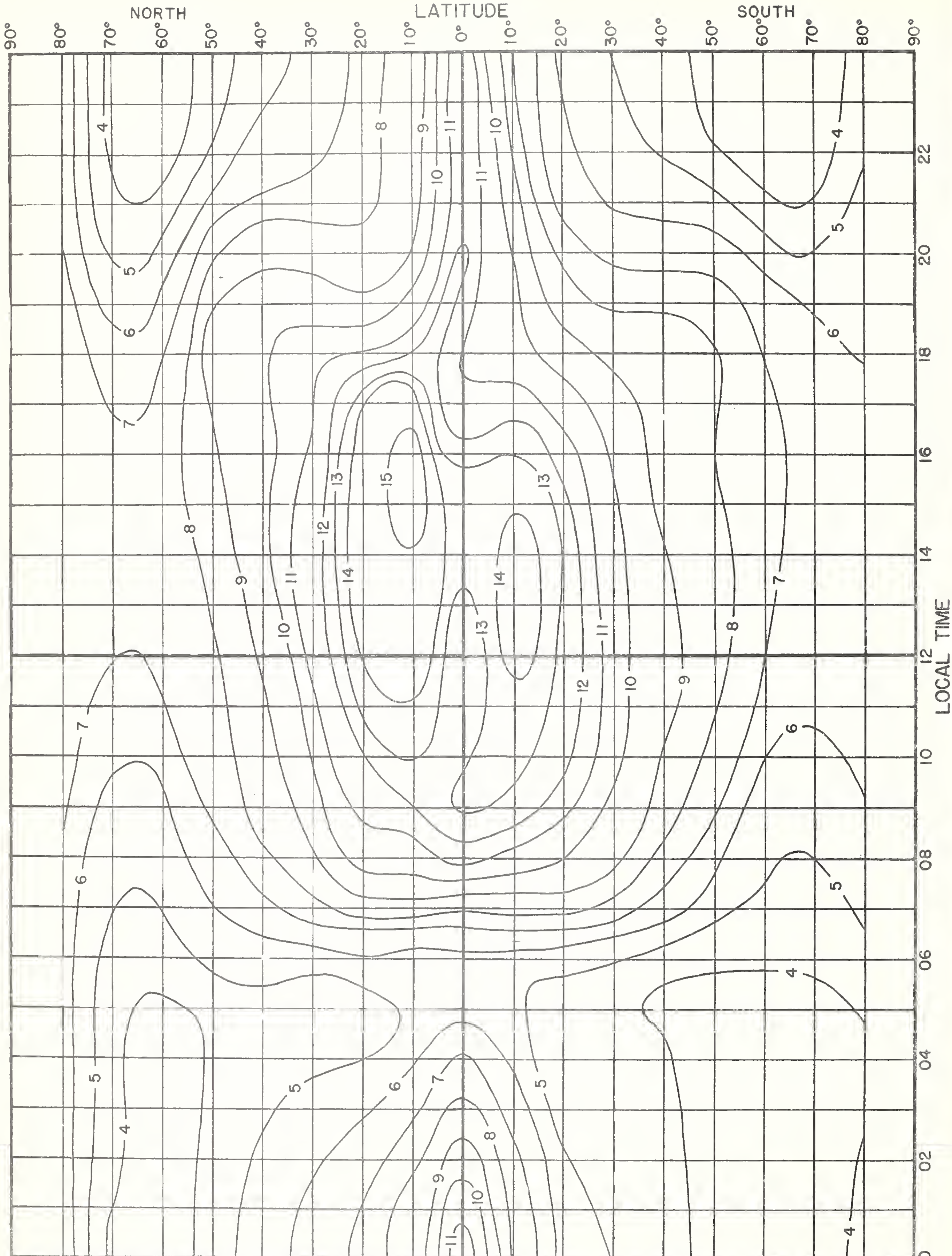


Fig 15. f°F2, IN Mc, I ZONE, PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 100

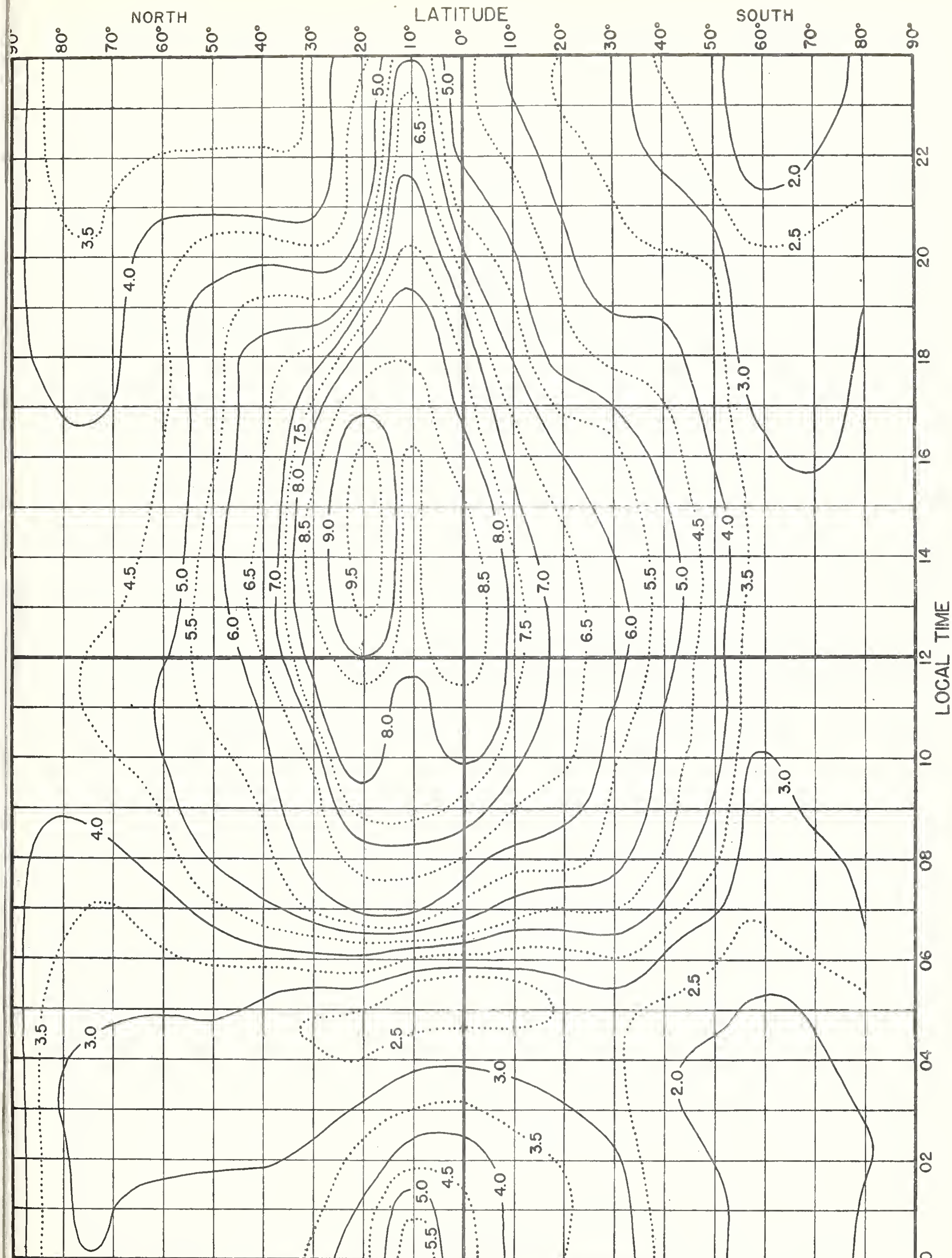


Fig. 16. f°F2, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 0.

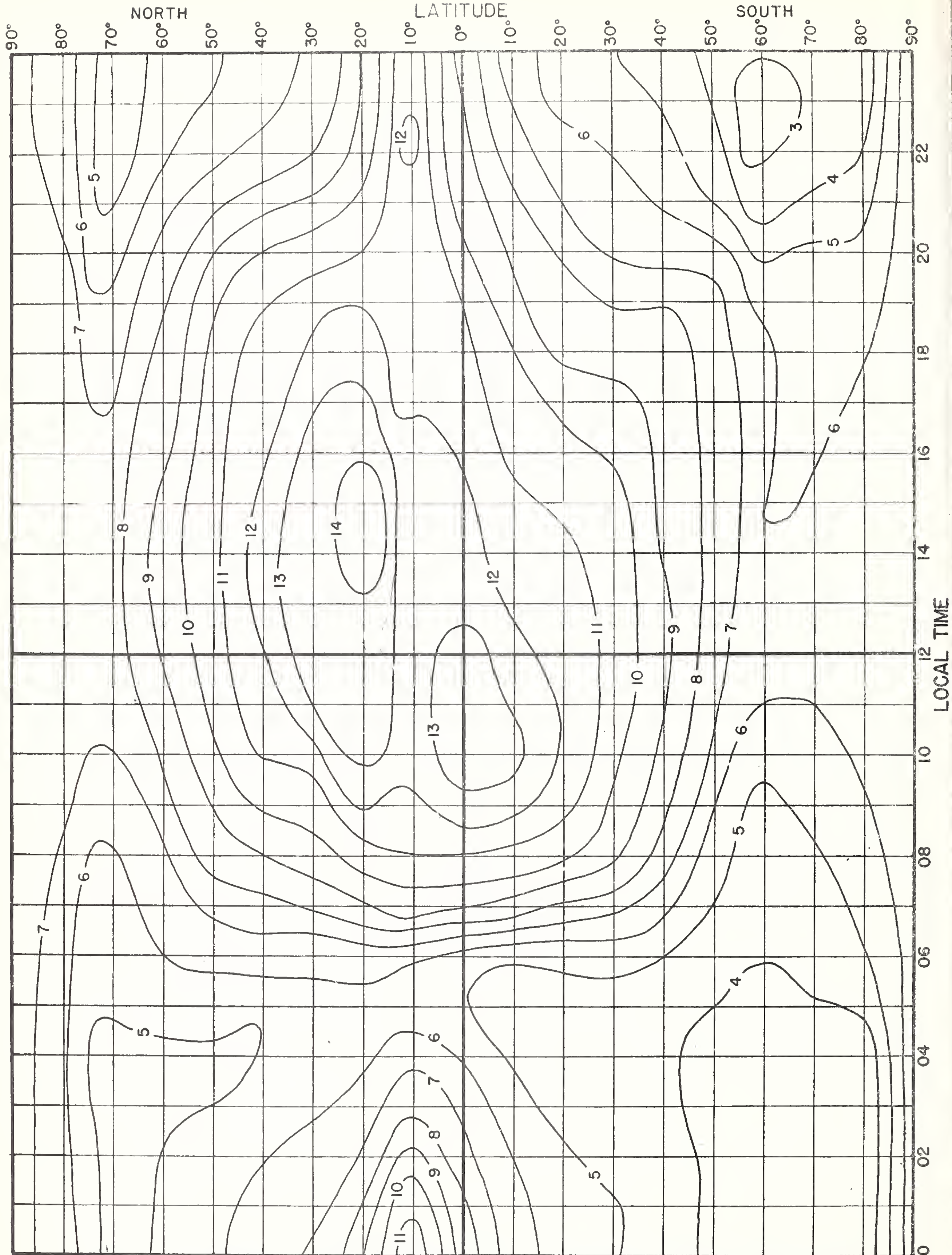


Fig. 17. f°F2, IN Mc, E ZONE, PREDICTED FOR SEPTEMBER, SUNSPOT NUMBER 100.

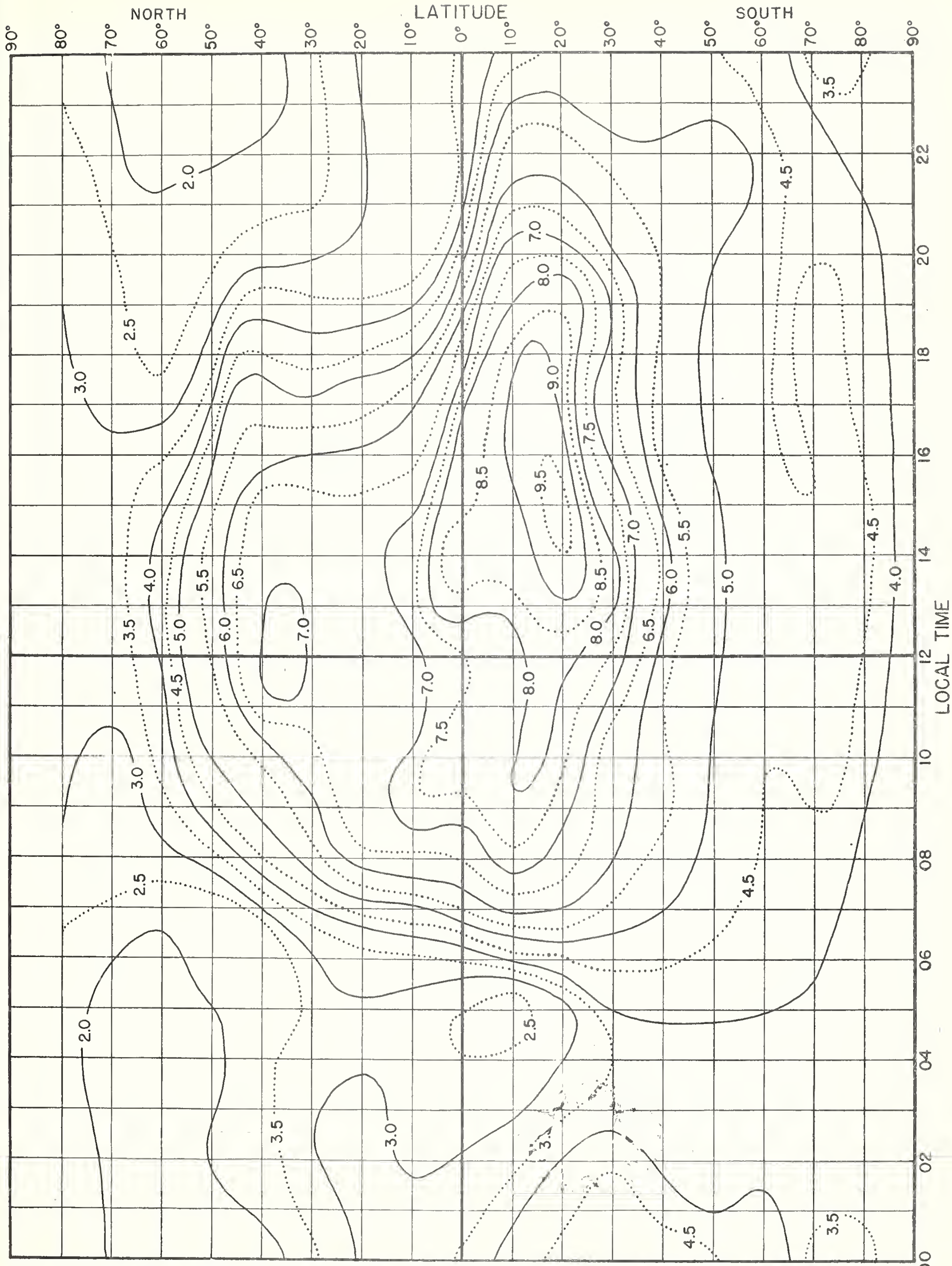


Fig. 18 f°F2, IN Mc, W ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 0

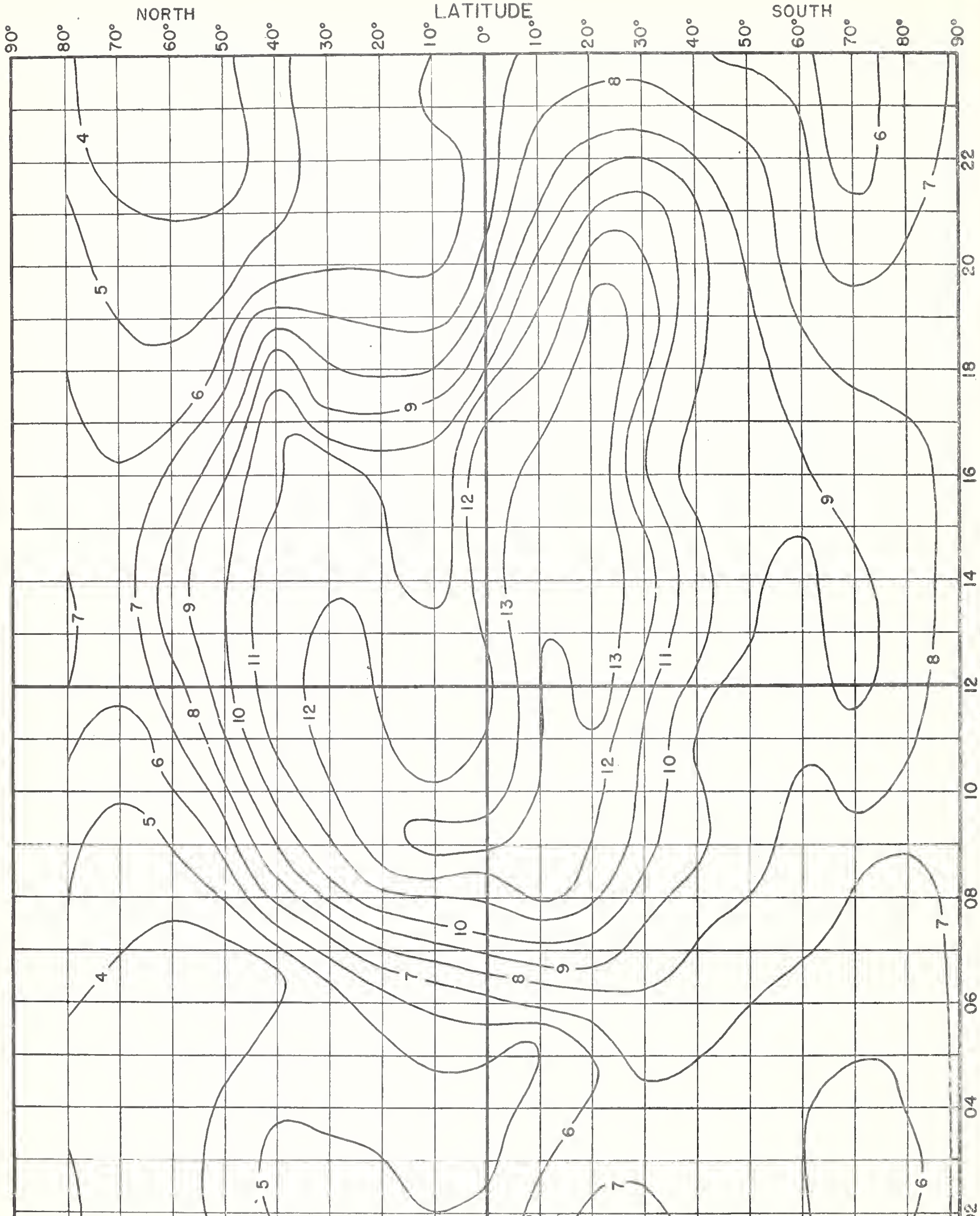


Fig. 19. f°F2, IN Mc, W ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 100.

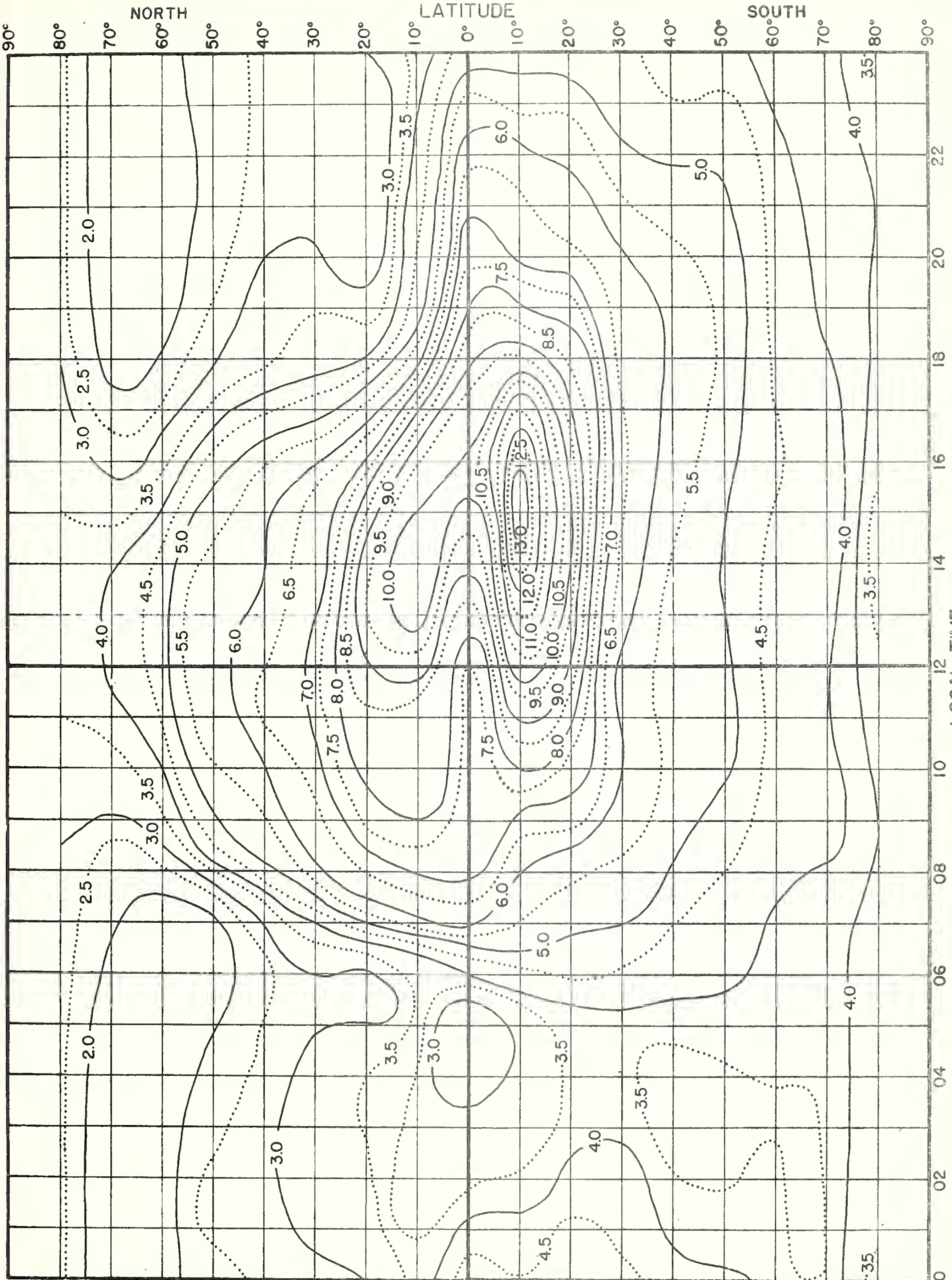


Fig. 20. f°F2, IN Mc, I ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 0.

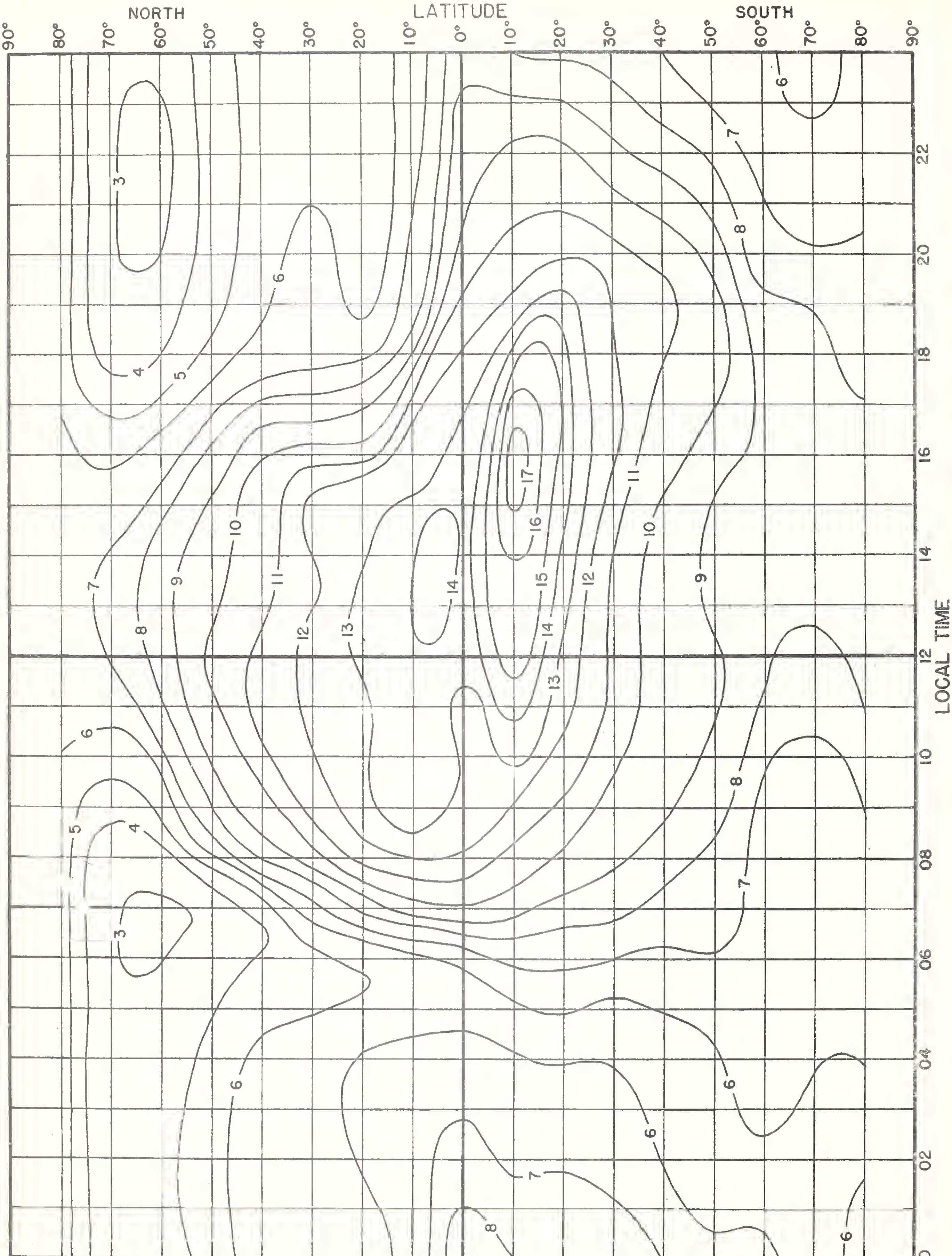


Fig. 21 f°F2, IN Mc, I ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 100.

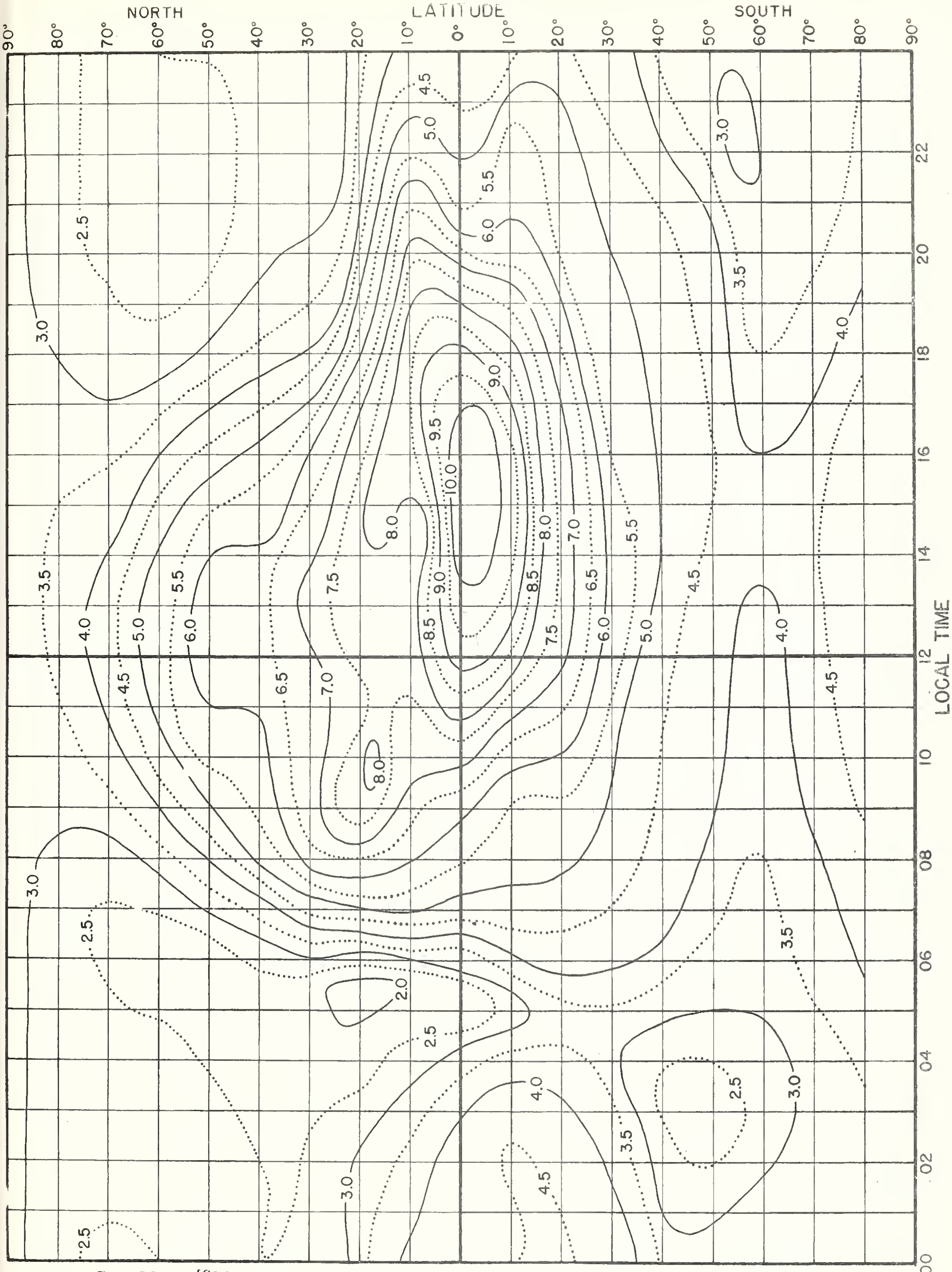


Fig. 22. f°F2, IN Mc, E ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 0.

176

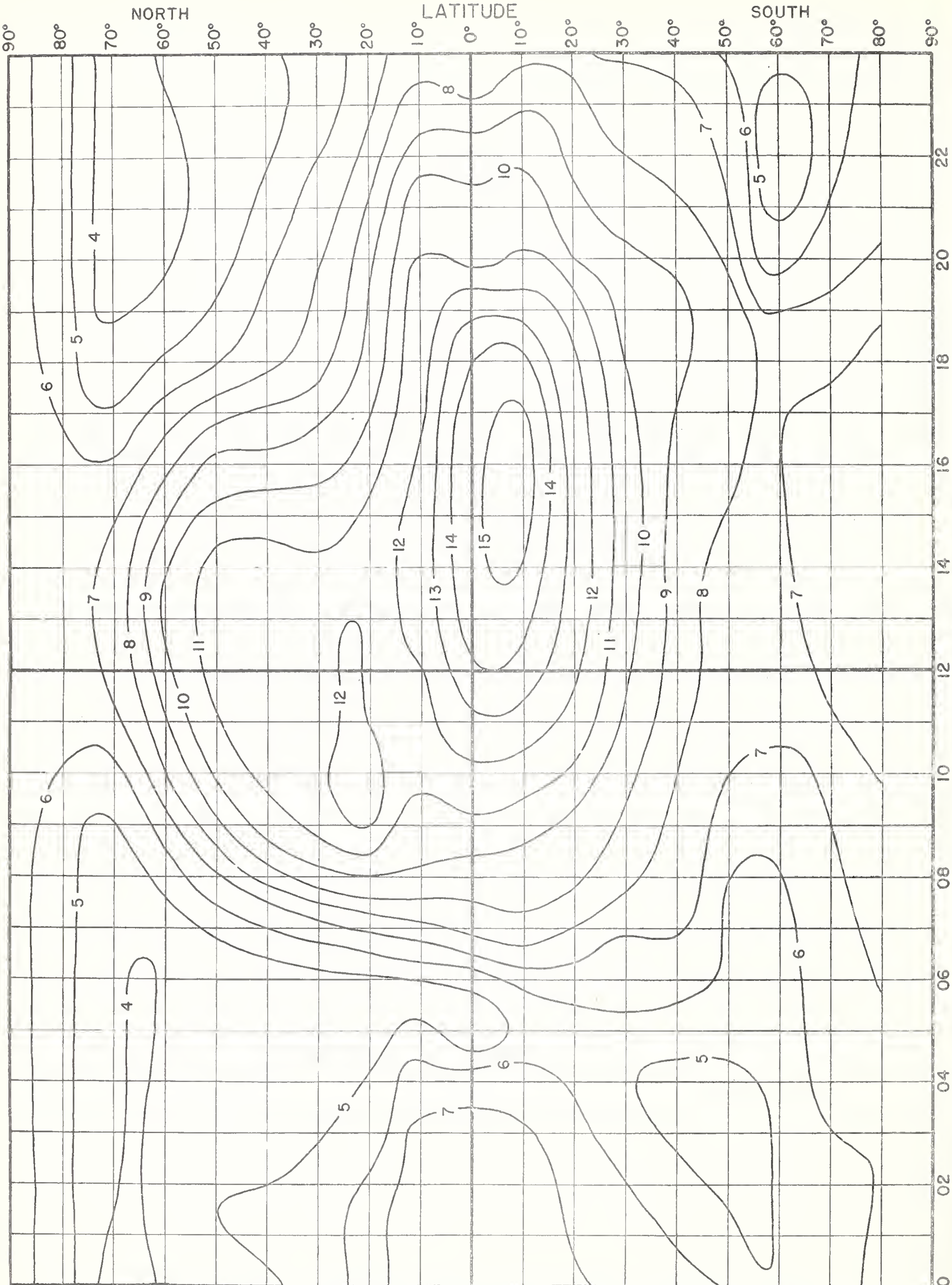


Fig. 23. f°F2, IN Mc, E ZONE, PREDICTED FOR DECEMBER, SUNSPOT NUMBER 100.

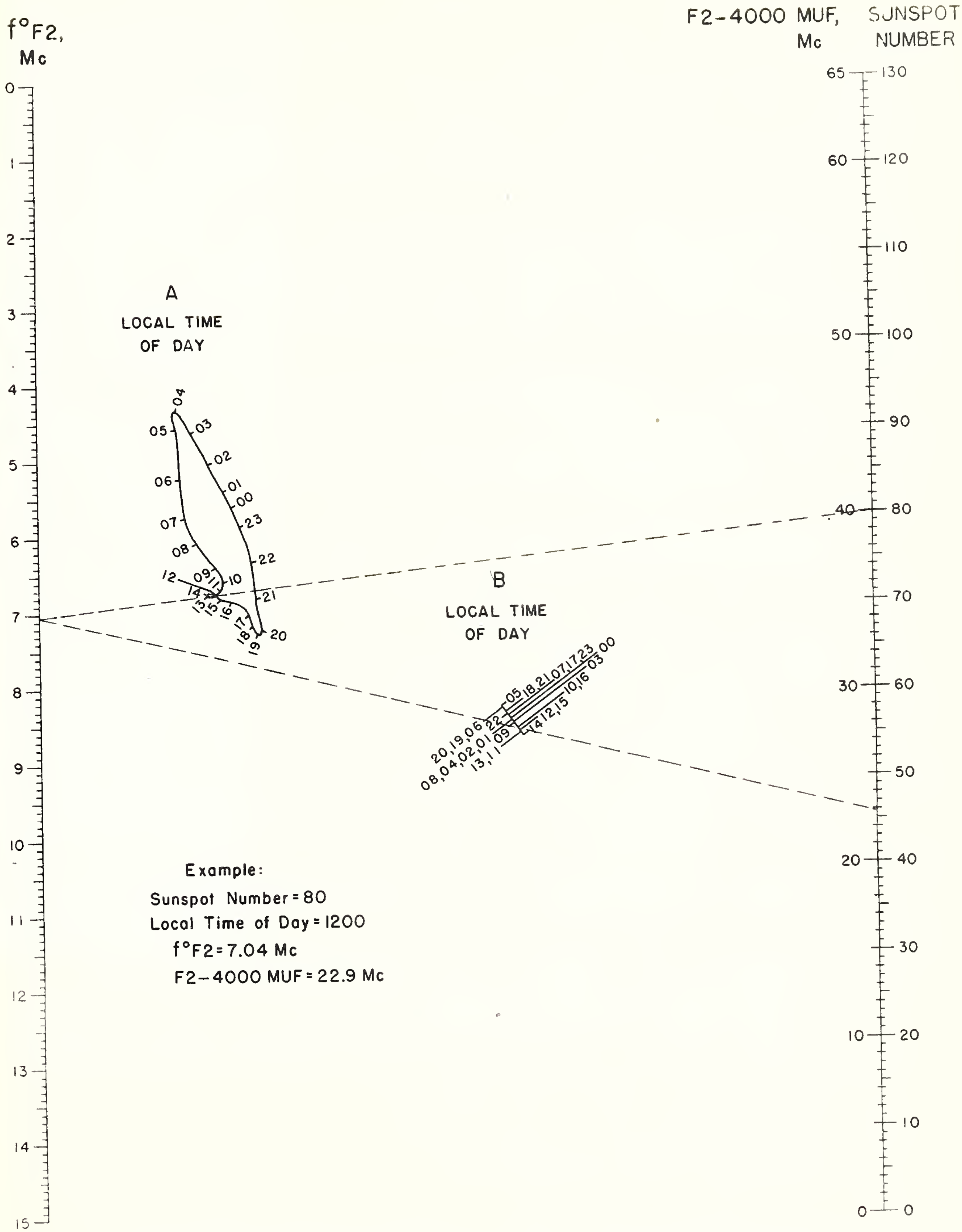


Fig.24. NOMOGRAM FOR OBTAINING f°F2 AND F2-4000 MUF THROUGHOUT THE SOLAR CYCLE.

W ZONE JUNE 40° N